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THE GRAPHIC REPRESENTATION OF RELATIVE VARIABILITY[1]

IT has been the generally accepted biometric practice to use the coefficient of variation as the measure of the *relative* variability or scatter of frequency distributions. This constant is

$$V = \frac{100 \text{ (standard deviation)}}{\text{Mean}}$$

It gives the standard deviation of the distribution in terms of the mean value of the varying character. By expressing the scatter of the distribution in this way it becomes possible to compare the relative variabilities of characters measured in different absolute units.

But the coefficient of variation has never been an entirely satisfactory constant to biologists, at least. While formally correct enough, within the limits of its definition, it does not readily or instantly call up in the mind an adequate picture of the real degree of scatter of the distribution. This is, in part at least, because two things, the mean and the standard deviation, are involved in it. When one reads the value of the standard deviation of a particular distribution he recalls that roughly three times this quantity on either side of the mean includes the entire frequency and this gives at once some concept of the biological extent and meaning of the variation, in the particular case.

There would seem to be a place of usefulness for an adequate graphical method of depicting relative variability for comparative purposes, so that one may *see* the difference or likeness in the variation of a man and a mouse, for example, in respect of body-weight. It is the purpose of this paper to describe such a graphic method, and to illustrate its applications.

The method may best be approached through a concrete illustrative example. We have lately been studying in this institute the normal variation and correlation of the relative cell volume of human blood, in relation to age, body-weight and stature.[2] The present situation regarding the measurement and graphical depiction of variation in these four charac-

[1] From the Institute for Biological Research of the Johns Hopkins University.

[2] *Cf.* Pearl, R., and J. R. Miner. "A Biometric Study of the Relative Cell Volume of Human Blood, in Normal and Tuberculous Males." Johns Hopkins Hospital Bulletin. In press.

TABLE I

VARIATION CONSTANTS

Character	Mean	Standard deviation	Coefficient of variation (per cent.)
a. Age	30.59 ± .21 yrs.	5.22 ± .15 yrs.	17.06 ± .51
b. Body-weight	151.56 ± .82 lbs.	19.95 ± .58 lbs.	13.16 ± .39
c. Stature	68.13 ± .10 in.	2.45 ± .07 in.	3.60 ± .10
d. Relative cell volume	45.59 ± .10%	2.47 ± .07%	5.42 ± .16

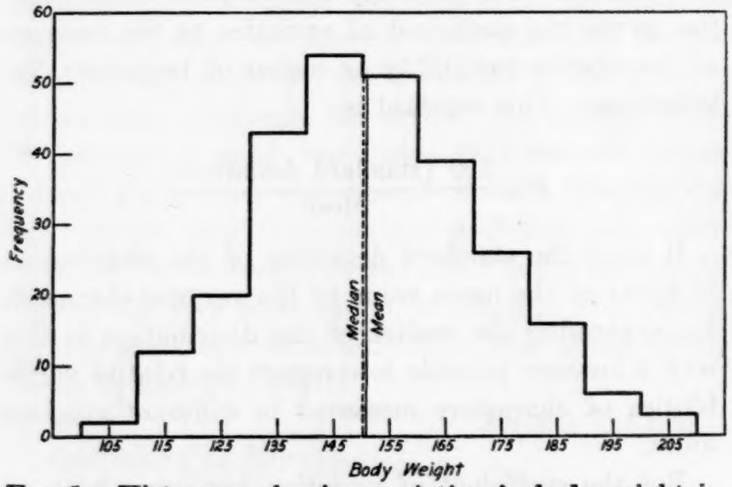

FIG. 1. Histogram showing variation in body-weight in a group of 272 normal males.

ters, in a series of 272 normal males, is fairly exhibited in Table I and Figs. 1 to 3.

Plainly the diagrams tell nothing whatever about the relative or comparative variability in this group of males in respect of the three characters, body-weight, stature and relative cell volume. They are correctly plotted histograms, but the unit of abscissal measure is different in each case and direct comparison is impossible.

From Table I we learn, through the coefficients of variation, that the group is from three to five times more variable relatively in respect of age and body-weight than it is in respect of stature or relative cell volume. But what does this mean translated into terms of distribution of frequency? A simple, direct and easily interpreted answer is not forthcoming.

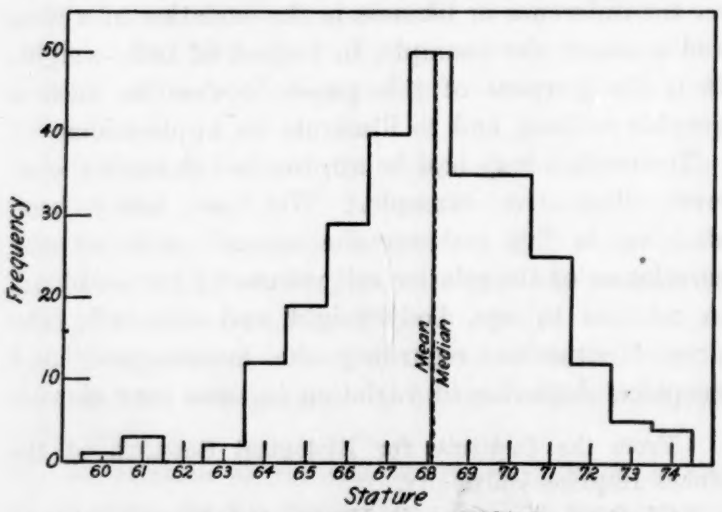

FIG. 2. Histogram showing variation in stature in a group of 272 normal males.

Suppose now we decide to express the age, the body-weight, the stature and the relative cell volume of each of these 272 individuals as a percentage of their respective mean values, the mean of each character being taken as 100 per cent. And further suppose we express the frequencies as respectively so much per one per cent. of the mean of each character. These are simple and entirely permissible transformations of the original data.

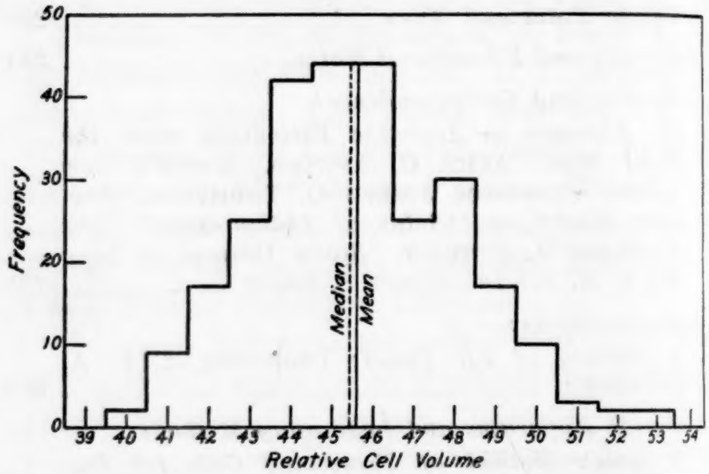

FIG. 3. Histogram showing variation in relative cell volume of the blood in a group of 272 normal males.

The data in their original form and after the transformation described are shown in Table II.

If now the figures in the columns headed A and B in Table II be plotted on arithmetically ruled coordinate paper we shall have a true picture of the relative variability of the four characters considered. This is done in Fig. 4. Each of the four frequency polygons has the same area, as a result of the transformations effected in the B columns.

This method of plotting superimposes the different polygons of variation on a common Cartesian coordinate grid, with the mean value for each of the compared variables at the same abscissal point. It constitutes no new method of *measuring* biological variation, but merely visualizes effectively what the coefficient of variation measures.

The method of plotting used in Fig. 4 shows at a glance that the 272 men of this group differ among

TABLE II

ABSOLUTE AND RELATIVE FREQUENCY DISTRIBUTIONS FOR VARIATION IN (a) AGE, (b) BODY-WEIGHT, (c) STATURE, AND (d) RELATIVE CELL VOLUME OF THE BLOOD IN 272 NORMAL MALES

Age				Body-weight				Stature				Relative Cell Volume			
		A	B			A	B			A	B			A	B
Class unit in years	Observed absolute frequency	Per cent. which mid-point of class is of mean	Absolute frequency per one per cent. of mean	Class unit in pounds	Observed absolute frequency	Per cent. which mid-point of class is of mean	Absolute frequency per one per cent. of mean	Class unit in inches	Observed absolute frequency	Per cent. which mid-point of class is of mean	Absolute frequency per one per cent. of mean	Class unit in per cent. of total volume	Observed absolute frequency	Per cent. which mid-point of class is of mean	Absolute frequency per one per cent. of mean
20–21.9	9	68.6	1.4	99.5–109.4	2	68.9	0.3	59.5–60.4	1	88.1	0.7	39.5–40.4	2	87.7	0.9
22–23.9	12	75.2	1.8	109.5–119.4	12	75.5	1.8	60.5–61.4	3	89.5	2.0	40.5–41.4	9	89.9	4.1
24–25.9	34	81.7	5.2	119.5–129.4	20	82.1	3.0	61.5–62.4	.....	91.0	.....	41.5–42.4	17	92.1	7.8
26–27.9	41	88.3	6.3	129.5–139.4	43	88.7	6.5	62.5–63.4	2	92.5	1.4	42.5–43.4	25	94.3	11.4
28–29.9	35	94.8	5.4	139.5–149.4	54	95.3	8.2	63.5–64.4	12	93.9	8.2	43.5–44.4	42	96.5	19.1
30–31.9	44	101.3	6.7	149.5–159.4	51	101.9	7.7	64.5–65.4	19	95.4	12.9	44.5–45.4	44	98.7	20.1
32–33.9	31	107.9	4.7	159.5–169.4	39	108.5	5.9	65.5–66.4	29	96.9	19.8	45.5–46.4	44	100.9	20.1
34–35.9	24	114.4	3.7	169.5–179.4	26	115.1	3.9	66.5–67.4	40	98.3	27.3	46.5–47.4	25	103.1	11.4
36–37.9	15	121.0	2.3	179.5–189.4	16	121.7	2.4	67.5–68.4	50	99.8	34.1	47.5–48.4	30	105.3	13.7
38–39.9	12	127.5	1.8	189.5–199.4	6	128.3	0.9	68.5–69.4	35	101.3	23.8	48.5–49.4	17	107.5	7.8
40–41.9	10	134.0	1.5	199.5–209.4	3	134.9	0.5	69.5–70.4	35	102.7	23.8	49.5–50.4	10	109.7	4.6
42–43.9	3	140.6	0.5	....	.....	....	.....	70.5–71.4	25	104.2	17.0	50.5–51.4	3	111.9	1.4
44–45.9	1	147.1	0.2	....	.....	....	.....	71.5–72.4	12	105.7	8.2	51.5–52.4	2	114.1	0.9
46–47.9	.....	153.6	.....	....	.....	....	.....	72.5–73.4	5	107.1	3.4	52.5–53.4	2	116.3	0.9
48–49.9	1	160.2	0.2	....	.....	....	.....	73.5–74.4	4	108.6	2.7	....	.....	....	.....
Totals	272	....	.....	....	272	....	.....	....	272	....	.....	....	272	....	.....

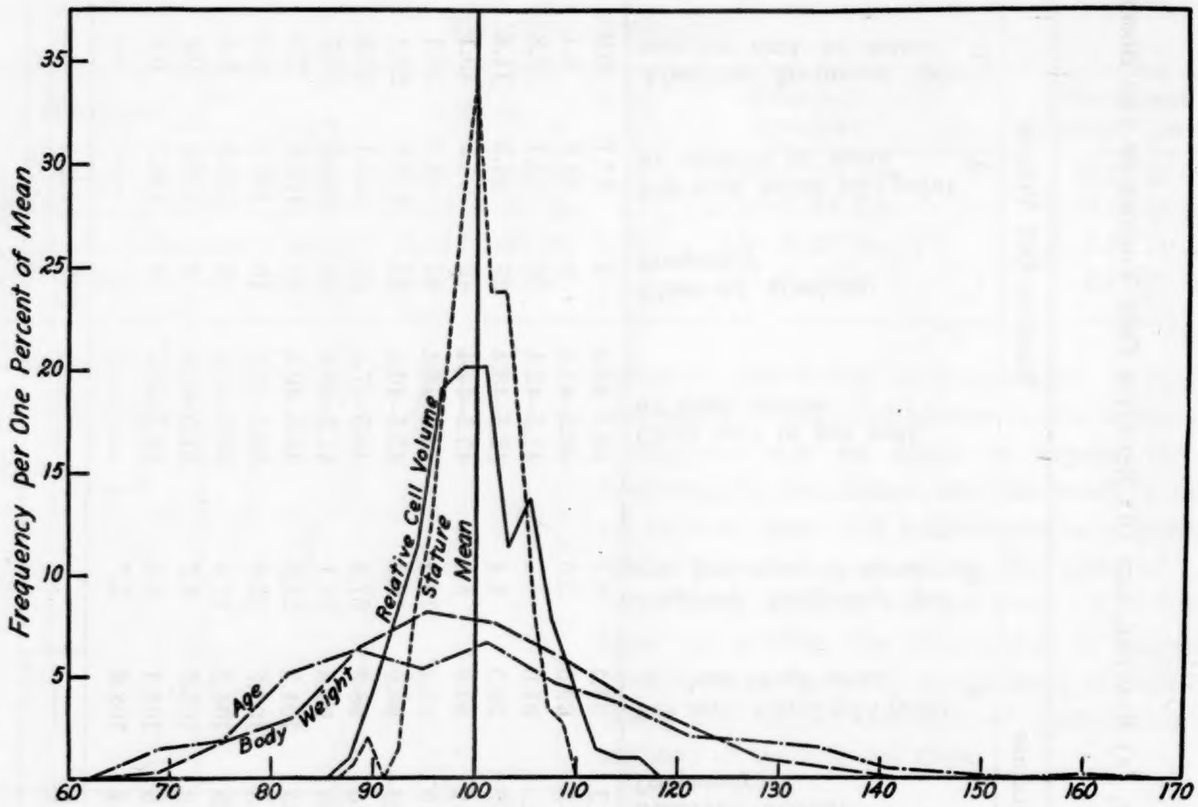

FIG. 4. Superimposed variation polygons for (1) relative cell volume, (2) stature, (3) body-weight, and (4) age, in 272 normal males. See text for further explanation.

themselves far more widely in respect of age and body-weight than they do in respect of stature or relative cell volume. The variation polygon for stature shows the least scatter. That for relative cell volume is somewhat, but not greatly, more spread. Those for age and body-weight are wide, flat distributions, indicating a relatively high variation in the group in respect of these characters.

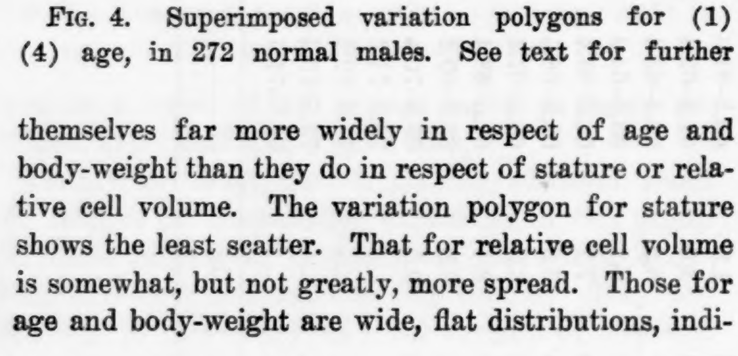

FIG. 5. Polygons showing the relative variability of cows in milk yield (solid line), and of hens in egg production (dash line). For further explanation see text.

One more example will be given. What is the comparative interindividual variability of cows in respect of milk production and of hens in respect of egg production? Table III gives the necessary data regarding (a) milk yield in gallons per week in three-year-old Ayrshire cows (combined years 1908–09),[3] and (b) annual egg production of Barred Plymouth Rock hens (1905–06, 150 bird pens).[4]

The coefficients of variation for the distributions of Table III are as follows:

Milk yield: $V = 17.690 \pm .229$.
Egg production: $V = 31.72 \pm 1.00$.

Using the data as given in columns A and C of Table III, Fig. 5 has been plotted. The transformation of the absolute frequencies per one per cent. of the means given in the B columns to the relative or per mille frequencies of the C columns is necessary in order to bring the two polygons to the same area, since the total observed frequency in one is 1,441 and in the other only 275.

[3] Pearl, R., and J. R. Miner. "Variation of Ayrshire Cows in the Quantity and Fat Content of Their Milk." *Jour. Agr. Research*, Vol. 17, pp. 285–322, 1919.

[4] Pearl, R., and F. M. Surface. "A Biometrical Study of Egg Production in the Domestic Fowl. I. Variation in Annual Egg Production." U. S. Dept. Agr. Bur. Anim. Ind. Bulletin 110, Part I, pp. 1–80, 1909.

TABLE III

Milk Yield		A	B	C	Egg Production		A	B	C
Class limits in gallons	Observed absolute frequency	Per cent. which mid-point is of mean	Absolute frequency per one per cent. of mean	Per mille frequency per one per cent. of mean	Class limits (number of eggs)	Observed absolute frequency	Per cent. which mid-point is of mean	Absolute frequency per one per cent. of mean	Per mille frequency per one per cent. of mean
6.50– 6.99	2	48.8	0.6	0.4	0– 14	1	6.3	0.08	0.3
7.00– 7.49	6	52.4	1.7	1.2	15– 29	1	18.8	0.08	0.3
7.50– 7.99	7	56.0	1.9	1.3	30– 44	4	31.4	0.32	1.2
8.00– 8.49	7	59.6	1.9	1.3	45– 59	10	44.0	0.80	2.9
8.50– 8.99	5	63.2	1.4	1.0	60– 74	21	56.5	1.67	6.1
9.00– 9.49	24	66.8	6.6	4.6	75– 89	23	69.1	1.83	6.7
9.50– 9.99	28	70.4	7.8	5.4	90–104	35	81.6	2.79	10.1
10.00–10.49	35	74.1	9.7	6.7	105–119	46	94.2	3.66	13.3
10.50–10.99	56	77.7	15.5	10.8	120–134	40	106.8	3.18	11.6
11.00–11.49	68	81.3	18.8	13.0	135–149	35	119.3	2.79	10.1
11.50–11.99	70	84.9	19.4	13.5	150–164	25	131.9	1.99	7.2
12.00–12.49	107	88.5	29.6	20.5	165–179	19	144.4	1.51	5.5
12.50–12.99	118	92.1	32.7	22.7	180–194	8	157.0	0.64	2.3
13.00–13.49	124	95.7	34.3	23.8	195–209	6	169.6	0.48	1.7
13.50–13.99	119	99.3	32.9	22.8	210–224	1	182.1	0.08	0.3
14.00–14.49	133	103.0	36.8	25.5	—	—	—	—	—
14.50–14.99	87	106.6	24.1	16.7	—	—	—	—	—
15.00–15.49	102	110.2	28.2	19.6	—	—	—	—	—
15.50–15.99	78	113.8	21.6	15.0	—	—	—	—	—
16.00–16.49	76	117.4	21.0	14.6	—	—	—	—	—
16.50–16.99	43	121.0	11.9	8.3	—	—	—	—	—
17.00–17.49	43	124.6	11.9	8.3	—	—	—	—	—
17.50–17.99	28	128.2	7.8	5.4	—	—	—	—	—
18.00–18.49	20	131.9	5.5	3.8	—	—	—	—	—
18.50–18.99	22	135.5	6.1	4.2	—	—	—	—	—
19.00–19.49	14	139.1	3.9	2.7	—	—	—	—	—
19.50–19.99	5	142.7	1.4	1.0	—	—	—	—	—
20.00–20.49	6	146.3	1.7	1.2	—	—	—	—	—
20.50–20.99	3	149.9	0.8	0.6	—	—	—	—	—
21.00–21.49	2	153.5	0.6	0.4	—	—	—	—	—
21.50–21.99	2	157.1	0.6	0.4	—	—	—	—	—
22.00–22.49	—	160.8	—	—	—	—	—	—	—
22.50–22.99	1	164.4	0.3	0.2	—	—	—	—	—
Totals	1441	—	—	—	—	275	—	—	—

The greater relative variability in egg production is apparent.

The general principle here developed for the graphic representation of frequency distributions may, of course, also be applied to regression diagrams.

RAYMOND PEARL

THE BIOLOGICAL RELATIONSHIPS OF THE LAND, THE SEA AND MAN

UP to the present time life in the sea has always been treated and considered as quite separate and distinct from the more familiar life on land. But this idea can no longer be maintained. The life of all the world is one vast unit, dependent for existence on the same sources of supply. The ocean life, though to most of us so strange and unfamiliar, is but the aquatic fringe of the life on land, and for the most part is supported by the same materials which, washed into the sea, no longer are available for the support of the land creatures.

Heretofore we have been led astray in our contemplation of sea life by the interesting fact that about three times as many major types of animals live in the sea as are found upon the land; indeed, of the major types of animals no less than ten, nearly half again as many as all land living types together, are exclusively marine.

This great variety in the form and structure of sea animals obscures another interesting fact. About three fourths of all known kinds of animals live on the land, and only one fourth in the sea.

The reason for these curious contrasts is not far to seek. All land animals have one thing in common. They must seek their food; it will not come to them. Therefore land animals are almost wholly of those types, arthropods and vertebrates, which are best adapted for locomotion, with representatives of some others of fair locomotor powers.

In the sea food substances not only lie upon the bottom, but they float everywhere suspended in the water, drifting back and forth and up and down. While useful, powers of locomotion are not essential for the creatures of the sea; if they can not seek their food it will be brought to them.

On land all creatures have to seek their food, but in the sea the food relations of the animals are of three kinds instead of one. Some, like the crabs, go after it, as do the animals on land; some, like the corals, attach themselves to firm supports, or, like the clams, burrow in the mud and let the water do the work of bringing food to them; and some, like jellyfishes, simply float about suspended in their food supply.

Three possible ways of securing food instead of one means a corresponding diversity in the fundamental structure of the animals involved. But the relative uniformity of conditions in the sea, especially in regard to the most essential substance, water, permits the existence of the numerous major types with relatively slight subdivision, in startling contrast to what we find on land where infinite variation in conditions has resulted in infinite variation in those few major types fitted to meet the exigencies of terrestrial existence.

The sea is commonly regarded as the place of origin of all animal life. But there is no real evidence that this is true. The reason for the supposition is to be found in the greater diversity of sea animals as contrasted with the animals on land and in fresh water.

Just as for many years we have commonly looked upon the sea as the place of origin of life, so also have we regarded it as the region where the primitive germs of life by an evolutionary process expanded into the forms we know to-day.

But very much of what biologists consider as the result of the evolution of the animal form is really nothing more than the necessary response to the physical restrictions of environment.

If you take the various forms of animal life and subtract from each those structural peculiarities which are immediately due to these physical restrictions imposed by their environment, you will see at once that the whole subject of the interrelationships of the major animal types takes on an entirely new aspect.

There is a most important trinity of factors affecting life in general that is not sufficiently appreciated. Life will be most abundant where there is a maximum of water permanently in the liquid state, a maximum of air and a maximum of food.

Thus on the land the optimum conditions for both plants and animals are in the moister regions of the tropics, where the rains are not so heavy as to be destructive by the weight of water falling, and the temperatures are high, but not too high, and constant.

But in the sea these factors find their most perfect balance in a region wholly different. For the colder water gets, the greater the amount of air and other gases it will hold in solution, and the longer will the organic matter in suspension or lying on the bottom be preserved. Thus in the sea the optimum conditions for both plants and animals are in the coldest oceans, in the polar seas in the summer time when the sun is at its highest, and in the cold currents flowing out from these.

Water, air and food are the three prime requisites for all organic life. The first two need not concern us further. Let us take up the last.

Our knowledge of the origin of the substances on which the plants and animals of the sea depend for their existence is very vague indeed. But the evidence seems to indicate that for the most part life in the oceans is dependent on foods brought down from the exposed land areas.

On land the frosts of winter and the heat of summer and the intermittent action of the rain by its mere weight alone as well as by the power of fresh water of dissolving solid substances, are continually wearing down the rocks. The products of this process of disintegration form our soils, and partly are delivered to the sea in the form of sands and muds and of various substances in solution.

On the soils grow plants of all descriptions, sometimes in great abundance, forming huge forests and extensive grassy plains, sometimes in less abundance.

All the animals on the land are of course supported by the plants, since only plants are able to form organic out of inorganic substances.

But there is a curious relationship between land plants and the animals that feed upon them that is commonly overlooked. In order to grow a plant must have a relatively large amount of green leaf surface exposed to the action of the sun's rays. If this be reduced below a certain minimum the plants will die. At the same time most plants produce more leaf surface than they really need. In the delicate balance of nature the difference between the actual necessities of the plants in leaves (or other structures) and the whole amount produced represents the food supply of

the insects and plant-feeding creatures generally, and the things that feed on them.

Nature is so adjusted that plant-feeding creatures, held in check by predators and parasites, never deprive the plants of more leaves than they can spare; and curiously certain plants when raised in the absence of their insect or other normal enemies grow better if their surplus leaves be cut away.

At the beginning of the winter or of the dry season the green leaves cease to function; they are of no further value to the plants. In most of our plants and in many in the tropics they wither and fall off.

The dying and falling of the leaves in autumn and at the beginning of the dry season, and more or less constantly at other times as well, means the accumulation of a vast reservoir of foodstuffs for anything capable of making use of it.

Bacteria and fungi thrive on this detritus, and earthworms, many kinds of snails and insects, as well as other creatures, feed either on this decaying vegetable matter, or on the bacteria and fungi in it, or on the living things that feed on them.

Much of this material is consumed where it lies upon the ground; but a vast amount is washed into the rivers, especially by the floods of spring and at the breaking of the rains, and goes into the sea. Much of this is still in a condition to be eaten by detritus-feeding animals. Much more, especially in the form of organic substances in suspension or solution, is available for food for the marine plants.

From the land there is thus delivered to the sea through the erosive action of the elements and the growth of plants a constant stream of foodstuffs.

Now, turning to the sea, we note at once two interesting facts. In the first place, sea life becomes scarcer with increasing distance from the land and toward the middle of the oceans almost completely disappears. The central south Pacific is a region far more barren than any desert area on land. No life of any kind has been detected in the surface water, and there is none whatever on the bottom. Manganese nodules, ear-bones of whales, and quantities of sharks' teeth are all that the dredge brings up. There is nothing living. Some of the sharks' teeth are four or five inches long and belong to a kind of shark that flourished in the Miocene, tens of thousands of years ago. Since the Miocene all the land areas have undergone great changes in their shapes and in the details of their surface sculpture; yet all this time these sharks' teeth have lain quite undisturbed on the sterile red clays of the ocean floor beneath the sterile sea.

Another interesting fact is that sea animals are largest and most abundant on those shores which have a copious rainfall, especially on rugged and on cold coasts where it may be assumed that material from the land would reach the sea unaltered in the greatest quantity.

As an illustration, the poverty of the sea life on the shores of the island of Barbados is most striking. As a detail, you at once remark the absence of those enormous starfishes so characteristic of the Caribbean region. Yet on the shores of the islands of St. Vincent and St. Lucia, to the west about one hundred miles, sea life of all kinds is abundant.

Barbados is low and flat, with a small rainfall and a small runoff. St. Vincent and St. Lucia both are very high and rugged with a very heavy rainfall, especially in the higher regions. Both support great forests in contrast to the cultivated sugar cane which covers most of the surface of Barbados.

In the East Indies also the large high islands of the Malayan archipelago, which are well wooded and have a heavy rainfall, support along their shores a wonderfully rich and varied fauna, while the fauna of the Polynesian coral islands remote from the great land masses is very scanty.

These facts would seem to demonstrate in a conclusive manner that life in the sea is dependent to a very large extent on the material derived from the exposed land surfaces. What other explanation is there to show why life decreases in abundance with distance from the land, becoming very scanty or quite absent in midocean, and why sea creatures are more abundant and of larger size on the shores of continents and of the large high rainy islands than on the shores of the small dry low-lying islands in the same latitudes?

But here we find an apparent paradox. In the Antarctic continent we have an exposed but frozen land mass which, so far as we can see, is not delivering food materials, especially organic food materials, to the sea in appreciable quantities. Yet along the shores of the Antarctic sea life is most extraordinarily abundant. This fact would seem to negative the inference just drawn.

Let us look more closely into this. The Antarctic Ocean water seems to be identical with the waters in the great depths of the other oceans, and the Antarctic seas thus seem actually to be simply a portion of the abyssal waters of the earth which here come to the surface, circulate about the Antarctic continent, run in great currents up the west coasts of South America (Humboldt current), Africa (Benguela current) and Australia (West Australian current), which currents turn gradually toward the west and sink beneath the warmer and lighter surface waters.

From such information as we have we believe the waters of the seas of the Antarctic to be the same as and continuous with the waters of the greater depths

in all the oceans elsewhere, and quite distinct from all the other surface waters.

What is the significance of this? Let me recall that plants require sunlight for their vital processes and that effective sunlight can not penetrate the water to a depth greater than at most six hundred feet under the most favorable circumstances.

But the substances washed from the land into the sea would not all remain above six hundred feet; they would become diffused at every depth down to the very bottom. Thus on the lee side of the West Indies the dredge brings up tree trunks and branches from many hundred feet beneath the surface. Much of the material washed into the sea, such as the finely ground and partially decayed remains of leaves, is in a form to be consumed directly by detritus-feeding animals. But much of it is in a form fit only to serve as food for plants living in sunlight. This material, falling below the thin illuminated surface layer of water into the dark and cold abysses, would there be preserved indefinitely. There it is useless for the support of life; but if that abyssal water should by any chance rise upward high enough to become illuminated, immediately this reservoir of food is made available for the consumption of the plants and through them for the support of animals.

In the Antarctic seas the cold abyssal water rises to the surface and the light. Here the substances it contains are immediately utilized by free floating plants, mostly the diatoms, which flourish in incredible abundance and support a vast array of animals of all kinds and sizes.

Thus the Antarctic marine life appears to be supported not by any local richness of the sea but by wash from the land masses in the temperate and tropical regions to the northward.

There is a curious difference between the diatom flora of the Antarctic and that of the Arctic seas. In both regions diatoms are amazingly abundant. But the Arctic diatoms are few in species and simple in structure, while in the Antarctic we find one of the most varied and elaborately ornamented diatom floras now existing. There the cruder and simpler naviculoid group so characteristic of the Arctic is in the decided minority, circular, polygonal and other symmetrical shapes being more common, and usually adorned with complex sculpturing and a variety of horns, spines and other ornamental appendages.

This superior richness, though not abundance, of the diatom flora of the Antarctic as compared with the Arctic must have some explanation, and I can not help believing that it has to do with a much more varied organic content of the water.

In the Arctic the substances transported from the land into the sea by the rivers and the runoff are relatively slightly variable in their composition. All of them come from much the same general type of vegetation, and all of them are transported by cold fresh water.

If we are right in our assumption that the Antarctic sea derives its water from the abysses of the other oceans, it is easy to see why the organic content of Antarctic waters should be much diversified. It would consist of materials derived from all types of vegetation, transported by cold and by warm waters, and delivered to the abyssal refrigerator in all stages of bacterial and other alteration. It would also contain much material of animal origin similarly diversified.

Conditions comparable to those in the Antarctic are found wherever abyssal water rises to the surface, as in those regions where there are seasonal upwellings.

From this it would appear that after all the Antarctic seas offer no obstacle to the assumption that the food substances in the seas are for the most part of land origin.

Now let us turn again to conditions on the land. An uncultivated area on land is so nearly balanced between the minimum requirements of plant life on the one hand, and the constant losses through the depredations of the insects and other plant-feeding creatures on the other, that human life can only be supported by subsisting chiefly on an animal, including insect, diet. The earliest human inhabitants of the earth must have been very few in numbers, and they must have fed chiefly on the destroyers of the plants, that is to say, plant-eating animals and birds and insects.

But we have learned to cultivate the land. Cultivation of the land may be described as the destruction of the original vegetation, the planting in its stead of those types of plants which yield us food and clothing, and, most important, the protection of these useful plants from their normal depredators.

We do this last instinctively to a large degree. For instance, we never bring an area under extensive cultivation until the large plant-eating animals have mostly been killed off.

At the present day there are far more human beings on the earth than there ever were before. Each one of us represent the forcible displacement and suppression of our equivalent in life of other types, the normal primitive predators upon the plants by which we live. The grasses are our most important crops. The grasses are the normal and the usual food of most of the hoofed animals, and of many rodents. These we have killed off and we flourish in their place.

Our existence at the expense of the hoofed animals,

the rabbits, rats and mice and similar other creatures, is nearing the saturation point; we are beginning keenly to feel the competition of the insects. Our further increase in the not distant future will be measured by the success we may attain in the displacement of the insects from their normal food which we shall ourselves consume.

Our future increase is dependent on the ability we may show to cut deeper and deeper into the ranks of those plant-feeding things that are competing with us for our food supply. The ability of our grandchildren to live will be measured by their ability to suppress their equivalent in insects.

What has the sea to offer for the future? Much less than is commonly supposed. In the sea the huge annual surplus of vegetable material so characteristic of the land does not exist. Except for a few flowering plants growing in shoal water near the coasts and the abundant sexual products of some algae, no sea plant bears special organs like the leaves of land plants which are discarded at the end of the growing season. There is no need for them to do so, as the humidity does not vary and the changes in the temperatures, if any, are very slight and gradual.

Life in the sea is a continuous cycle without the enormous annual waste of organic substance that characterizes life on land. In the sea when the minute plants called diatoms increase in numbers this phenomenon is promptly followed by an increase in those small creatures, especially the copepods, that feed on them. Increase in the copepods is followed by an increase in the number of the copepod consuming fishes, and these serve to attract predaceous fish and mammals that feed on them. When, owing to changed conditions, the numbers of the diatoms fall off, the copepods in their turn become less numerous. The fishes, however, swim away and seek their food elsewhere, followed by the predaceous fishes, dolphins, porpoises, etc. The annual cycle in the sea is a cycle of continuous, though changing, life, and there is almost no organic waste. If a large creature dies, it is soon consumed by the other creatures of the sea. On the bottom muds live many scavengers that feed upon whatever falls down from above, many swallowing the mud and digesting out of it the half-decayed remains of diatoms and copepods and other things.

Probably the extensive ooze deposits on the bottom of the seas mostly represent the shells of shell-bearing animals, diatoms, etc., from which the organic matter largely had been eaten or digested before they fell. Were this not so we should expect to find upon the oozes much more abundant life than there exists.

Of the products of the sea we eat plant feeders, predators of plant feeders, scavengers and detritus feeders. We eat sea plants only in wholly negligible quantities. Our relations with the sea to-day are just the same as those of the most primitive of mankind were with the land. Just as primitive man found the uninhabited lands the most productive, so we find the uninhabited coasts the most productive. Any large increase in sea products must come mostly from the exploitation of new areas. By the elimination of the present waste and by proper conservation the amount of food drawn from the sea can be more or less increased in the populous regions, but the possibility of increasing the productivity of sea areas already being utilized is infinitely less than the possibilities of similar efforts on the land.

The interrelationships of the land and sea as set forth above are not yet proved, but all the evidence seems to point in that direction. On our utilization of the land depends the productivity of our adjacent seas. For instance the unrestricted use of streams for industry by the pollution of the water not only kills off such aquatic life as they contain, but, more important still, decreases the value of the substances brought down for the support of marine life.

Intensive cultivation of extensive areas on land not only greatly lessens the amount of vegetable detritus washed into the sea, but also permits the washing off from the land surface of quantities of mud and sand. Such detritus as goes down a very muddy river is largely buried when the sand and mud sinks to the bottom on the ocean floor, or is so diluted with mud particles as to make it unavailable for use by detritus feeding animals. Furthermore, in a muddy river mouth only a small part of the available material can be used by plants, since the sunlight in effective quantities can only penetrate for a few feet through the clouds of mud.

For centuries the land areas have been subject to intensive study. The similarly intensive study of the seas is yet to come. We see our way to an increase in the products of the land. We see at present no such simple way of increasing the products of the sea.

We can not escape the inference that at the present time and in the future we should especially devote ourselves to the problem of displacing the competing insects on the land, and to an intensive study of the seas, especially with a view to ascertaining what it is that feeds the life in them, the nature, extent and quantity of that life and how we may conserve and utilize it to the best advantage.

Smithsonian Institution Austin H. Clark

NOTES AND REFLECTIONS ON ISOSTASY

If the earth's materials were sufficiently plastic to allow of a condition of perfect equilibrium, these materials would arrange themselves in concentric strata according to density, and there would be no

surface irregularities. But in the actual earth, owing to the resistance to flow of the crustal materials, perfect equilibrium is not reached. Wherever denser material remains at the same level as lighter material, and wherever portions of the crust are not in complete equilibrium, there will be stresses and a tendency to readjustment.

It is reasonable, as well as convenient, to assume that there is some uniform depth of equal pressure, below which there is perfect equilibrium, and above which there is that close but imperfect condition of adjustment called isostasy. Isostasy might exist in the earth's crust with an indefinite number of combinations of varying crustal densities and depths, falling within two extremes. At one extreme is the theory that the depth of crustal effect is uniform, and that the unit columns above that depth have equal weights, with densities differing according to the height of the columns, thus with less density beneath mountains and greater density beneath ocean beds, but with the density in any one column uniform. This is the hypothesis used, for convenience of computation, in the Hayford gravity reduction method, excepting that the depth of compensation was taken as being uniform from the earth's surface, therefore having the same irregularities as that surface. The other extreme theory assumes that the crustal material is of uniform density, and does not extend to a uniform depth but projects into a heavier substratum sufficiently to maintain the elevated regions in equilibrium; the depth of equal pressure then becomes the depth of the deepest projection, and the unit column of equal weight above that depth includes more or less of the subcrustal material. In the former, but not in the latter, the depth of equal pressure and the depth of crustal effect would be identical. These have been referred to respectively, as the Pratt and the Airy theories, though not proposed so definitely by either. Pratt recognized horizontal compression due to a contracting crust, as well as vertical contraction and expansion, as explanatory causes of crustal conditions, and followers of Airy have recognized greater density beneath ocean beds as a factor in equilibrium.

That the actual crust does not conform to either of these extreme theories is evident from the known differences in the density of crustal materials. As regards the second theory, local crustal rigidity makes it unnecessary to assume that there are "roots" having sufficient depth to support mountain peaks separately. There are several factors which would tend to reduce considerable protuberances, if they ever existed, as, for example, the lateral pressure of the adjacent denser materials of the substratum, and the horizontal movement beneath the outer crust. As regards the first theory, the magnitude of the forces, whatever their character, necessary to have caused existing surface irregularities and subsurface flow would be likely to cause material departures from uniformity in the depth of crustal effect. It may be that the actual condition of the crust is well within either of these extreme limits, but with the probabilities against considerable protuberances into the substratum, and also against a uniform or a well defined depth of crustal effect.

It should be noted that the meaning of isostasy is broad enough to cover any condition of crustal equilibrium within these extremes, and there is no ground on which the use of the word can properly be restricted to some particular theory of equilibrium, at least until such theory is confirmed.

Isostasy is now a much discussed subject, but thirty-three years ago there was quite "low visibility" as to the interpretation of gravity results with respect to this theory. In applying the old methods of reduction to the important series of gravity determinations made in 1894 and 1895, I found the results so discordant that there appeared to be no clear proof of any theory as to the condition of the earth's crust. Acting on a long neglected suggestion, I then developed a reduction method which in effect applied approximately a compensation for the elevation of the region about a station as though it were leveled off, instead of a compensation for the station elevation itself. When this method was applied to a considerable number of stations well located and distributed, it showed uniformly good results, and for the first time in gravity reductions the large residuals disappeared, and all the gravity results became consistent with isostasy. I used for this test 67 stations, including besides the transcontinental series, determinations in several continents, and island stations in two oceans, and every group of these showed consistently small residuals with this average elevation reduction.

At the time, I referred to these results as leading "to the conclusion that general continental elevations are compensated by a deficiency of density in the matter below sea level," and the only limitation I put on the closeness of compensation was that "local topographical irregularities, whether elevations or depressions, are not compensated for," and the meaning of this limitation was explained in another place; "as, for instance, the attraction of a mountain on a station at its summit or of an isolated island." Referring to a group of stations near the Gulf coast I said that "the smallness of the differences found indicates a close approach to the condition of hydrostatic equilibrium in this region," and referred to this reduction method "as further confirming the validity . . . of the equilibrium or isostatic theory."

The results of the extensive investigations following the development by Hayford in 1909 of a more rigorous method of gravity reductions permit additional light to be thrown on this earlier work. It has now been shown that there is substantially no difference between the gravity results on an assumption of perfect local isostasy and those on an assumption of regional compensation to some radius perhaps approaching 100 miles from the station. Therefore the average elevation method of 1895 should give similar results, which it does. It gave average anomalies substantially as small as the later results by the Hayford method, and it eliminated the large residuals as completely. It did not, however, as was then thought, prove that local features are not compensated. But the inference at the time that features of the order of a single mountain are not locally compensated is perhaps near the truth. A mountain is in general probably compensated, but it is evident that through partial rigidity the compensation is distributed beyond the area of the base, as a part of the compensation of the surrounding region; the method of distribution is, for obvious reasons, difficult or impossible to detect with the pendulum.

Hayford in his gravity work adopted a rather extreme view in favor of local compensation, as is shown by his prediction of complete adjustment to some limit between one square mile and one square degree, by his conclusion that the area that may be regionally compensated is probably less than 12 miles in radius, and by his selection of zones for the gravity reductions, the first zone having a radius of only 2 meters, and there being 11 zones within a radius of 12 miles from the station.

The 1895 work has further significance in that a different computation method leads to similar general results as to isostasy, and also in that it shows that close average results may be obtained by an approximate method which makes no assumption as to the depth, thickness or density arrangement of the compensation. Incidentally a gravity reduction method was developed which gives close approximate results by a very short computation, the correction for attraction and compensation being simply 0.0001059 multiplied by the difference in meters, between the average elevation within 100 miles and the station elevation (this constant being for an average surface density of 2.56). A subsequent result has been an explanation of wherein the so-called "free air" reduction method failed.

The reduction and discussion of the 1894 and 1895 results were done in a few months of individual work. At the time, an eminent geologist made independent computations, and drew his own conclusions as to isostasy being limited by very broad areas of rigidity, conclusions which he later abandoned, and to which I gave little heed. But as a consequence, views which I have not held have inadvertently been attributed to me. I did not conclude that mountain ranges or systems were not in equilibrium, nor that isostatic adjustment was limited to broad areas such as that of the United States as a whole. In fact I did not consider that the 1895 work gave evidence as to the limiting size of areas regionally compensated.

In the brief references to the 1895 work in the official publication of 1912 there are also some misunderstandings. As stated above, the average elevation reduction was applied at 67 stations, instead of only at the one group of 14 stations as mentioned. I did attach importance to the smallness of the anomalies derived by this method, and gave numerical and graphical comparisons with older methods showing the large reduction accomplished in their average size for each group of stations, whether on continents or on oceanic islands. My statement was only to the effect that the remaining anomalies would not have particular significance as respects the individual stations, because of the approximations used.

In this latter respect the results of the Hayford reduction method made an advance over any previous work. But it must be remembered that even this reduction, the most rigorous that has been developed, is based on a number of assumptions and approximations, and is not free from the possibility of appreciable systematic error; an indication of this is found in the comparison of anomalies for pairs of stations of considerable difference of elevation, where in practically every case subtraction of the anomaly of the lower from that of the higher station gives a positive difference, the average difference for the 16 available pairs of stations being +0.022 dyne, and the maximum (Mauna Kea-Honolulu) being +0.131 dyne. Omitting this maximum, the average difference is still +0.014 dyne, an appreciable uncertainty, since the average gravity anomaly in mountainous regions is about this amount. Mauna Kea is one of the most notable gravity determinations of the world, as the station is about 18,500 feet above the average elevation of the surrounding region, allowing for the density of sea water. While there is incompleteness in the topographic data, this large difference may have some real significance as respects reduction methods, as it is fairly consistent with the other pair differences, considering the difference in elevation. There is a group of other Hawaiian determinations by Preston which should have similar interest.

A gravity measurement of geological interest was made by me in 1896 at Umanak, Greenland, in latitude 70° 40′. This station, deep in the fjords and

near to the edge of the ice cap, is about 1,000 feet below the average elevation of the surrounding region. Using the incomplete topographic data and an approximate reduction, the small anomaly indicates fairly normal gravity here. Another determination of special interest, two years later, at St. Michael, Alaska, in latitude 63° 28′ N., adjacent to the great Yukon delta, also shows approximately normal gravity.[1]

GEORGE R. PUTNAM

WASHINGTON, D. C.

SCIENTIFIC EVENTS

CONCILIUM BIBLIOGRAPHICUM

THE arrangement whereby the Concilium Bibliographicum (Zurich) has received certain financial support during the last five years from the Rockefeller Foundation through the National Research Council, and whereby the council participated in the management of the concilium, terminated with the end of 1926, a termination provided for by the terms of the arrangement as originally made.

This termination of the arrangement referred to in no way indicates a disapprobation of the concilium's service either on the part of the Rockefeller Foundation, the National Research Council or the American users of the service.

This service, it may be briefly explained to those readers of SCIENCE not already familiar with it, is the preparation and distribution of bibliographic references in current zoology and certain allied fields on cards giving author and title references arranged according to a convenient subject classification. These cards are sent to subscribers at a reasonable rate. Subscription may be for the whole series of cards or for parts of the series referring to particular subjects.

Despite the cessation of the American subsidy, the concilium expects to continue its work, as it has been able to find some special financial support in Switzerland and Germany. It needs, however, more support than it has yet found and would be glad if its American friends could give it further financial aid.

American subscribers who have been paying their subscriptions through the National Research Council are requested to make payments hereafter to the Equitable Trust Company, 77 Wall Street, New York City, "for Concilium Bibliographicum Account, Len & Company, Zurich," and to address all inquiries and other correspondence directly to Concilium Bibliographicum, 49, Hofstrasse, Zurich.

Concilium Bibliographicum was founded in 1895 by Dr. H. H. Field, of Harvard, and has now for director Professor J. Strohl, of the University of Zurich. The difficulties created by the great war and by the death of Dr. Field soon after the close of the war nearly overwhelmed the Concilium, but the co-operation of the National Research Council, with the financial assistance of the Rockefeller Foundation, and the vigorous and devoted efforts of Director Strohl, saved the situation, and the Concilium was enabled to catch up and go on with its work.

Despite the recent establishment of *Biological Abstracts,* a periodical form of biological bibliographic service urgently recommended by the Union of American Biological Societies and by the National Research Council, and established by the financial aid of the Rockefeller Foundation, there will probably always be a considerable number of American zoologists, especially taxonomic workers, who will find the concilium cards convenient and useful. These zoologists will be glad to learn that the concilium expects to continue its service.

VERNON KELLOGG

NATIONAL RESEARCH COUNCIL,
WASHINGTON, D. C.

THE BOTANY SCHOOL OF THE UNIVERSITY OF SYDNEY

THE opening of the new botany school in the University of Sydney is an event not only important for the British Empire, but also for the world at large. The building is in modernized perpendicular Gothic and harmonizes with the main structure of the University of Sydney, which presents some interesting resemblances both in its architecture and its origin to the well-known main building of the University of Toronto. The construction is in stone and the building is so arranged that it will be an ornament to the university for many years. Although architecturally attractive, it does not represent the petrification of the science in the Pierian springs of architecture rightly dreaded by Thomas Huxley, for it is thoroughly well lighted, spacious and in every way practical. The entrance is adorned by representations of some of the great masters in the science. The idea of commemorating the great, however, is not confined to the exterior of the building, for the laboratories and other workrooms are named after distinguished botanists. The botanical museum bears the name of Bentham and Hooker and its windows show the portraits of such outstanding botanists as Hofmeister, Grew, Sachs, Nageli, Hooker, Bentham and others. The herbarium, which is spacious and well equipped, is

[1] These notes are a summary, with additions, of paper "The Equilibrium Theory of the Earth's Crust," in the *Journal* of the Washington Academy of Sciences, June 4, 1926, where detailed explanations and references are given.

named for John Ray and in its windows appear effigies of Morrison, Ray, Tournefort, De Jussieu, Linnaeus, Robert Brown, etc. The advanced laboratory is named for Charles Darwin. The research laboratory bears the name of Robert Brown, while the first-year laboratory is named after Sir Joseph Banks, two names so signally connected with the beginnings of Australian botany.

The library and reading rooms provide abundance of space, but the shelves are as yet meagerly lined with books. It is hoped that this shortcoming may, before long, be remedied in view of the great interest which the public in Sydney has begun to take in botanical science.

A physiological laboratory is also among the rooms in the botany school and it supplies excellent facilities for the prosecution of that important side of the science. Numerous research rooms for the staff and advanced students are included in the plan of the building and last, but not least, the lecture theater is capable of seating 200 students.

The building was formally opened on November 6, in the presence of the governor of New South Wales, the vice-chancellor of the university and Professor Anstruther Lawson, the head of the school. Professor E. C. Jeffrey, of Harvard University, was present as guest of honor to deliver an address and also the formal felicitations of Harvard University.

The opening of the new botany school in Sydney University is a scientific event of the first magnitude because it supplies an equipment in the Southern Hemisphere in every way adequate for the carrying on of botanical investigation. The facilities provided by the botany school, in fact, compare most favorably with those which are offered by the larger universities in the Northern Hemisphere. In his remarks the guest of honor referred to the great advantages which Australasia presents to the students of plants, combining as it does, a great variety of environment with healthful conditions of existence and a stable and well-organized government. Australasia, in fact, unites to to a large extent the advantages of the tropics with the comfort and salubrity of temperate regions. The flora of Australia is quite as interesting as its fauna, but not nearly as well known. It was suggested, further, that it would be a great advantage if every student of botany in the Northern Hemisphere could some time or other visit Australasia. Professor Lawson, in the name of the university, offered the full hospitality of the botanical laboratory to visiting botanists and expressed the hope that more and more of these would feel encouraged to make the journey to Australasia, with the knowledge that there they would find facilities equal to those of the best tropical gardens.

The botany school of the University of Sydney is a monument to the zeal, capacity and artistic sense of its head, Professor Anstruther Lawson. It is to be hoped that he may live long to preside over the department which he, himself, has created and that botanists in numbers from other parts of the world may have the opportunity of enjoying the delightful hospitality of Sydney and its university. It has already a large and growing body of students and a highly creditable list of published researches.

E. C. J.

THE INSTITUTE OF CHEMISTRY OF THE AMERICAN CHEMICAL SOCIETY

Formation of the Institute of Chemistry of the American Chemical Society, which, beginning this year, will bring together every summer at a center of technical education chemists from the nation's laboratories of industry and education, has been announced following action by the executive committee of the society.

George D. Rosengarten, president of the society, has made the following statement:

The American Chemical Society has approved the suggestion that an Institute of Chemistry be held annually as one of its projects for the promotion of the science in America.

The Chemical Foundation, Inc., and the Pennsylvania State College have agreed to furnish the funds to put the plan in operation for the first session, to be held during July, 1927, at Pennsylvania State College. Northwestern University has requested the privilege of being the second university to cooperate with the society and the session of 1928 is to be held at Evanston. Places for the third and subsequent sessions remain to be chosen.

The purpose of the Institute of Chemistry is to offer a series of lectures and demonstrations whereby those in attendance may be brought quickly up to date in fields both within and outside their own specialty, and to afford facilities for teachers to acquire the latest information in chemical science as well as to benefit from the contacts with the industrial and consulting professional chemists.

It is planned that teachers and others desiring to do so can take the stated courses in chemistry throughout the summer school and receive credit therefor, so that in a combination of the Institute of Chemistry of the American Chemical Society and the regular summer school courses of Pennsylvania State College the requirements will be met.

The contacts between groups of individuals we consider an important factor in the attractiveness of the plan. There are very few chemists, whether they be in industry or academic life, who have not longed for such an opportunity to meet the leaders of their profession. The most profitable contacts are those formed during periods of leisure and relaxation, provided by the institute plan.

Arrangements have been made to house the members of the institute in convenient groups, and all will come together at meal time. In a new fraternity section, twelve modern houses—none more than three years old and all attractively furnished—will be reserved for institute members. Experience has shown that these details, as developed by the Institute of Politics at Williamstown, are highly beneficial.

THE ELLA SACHS PLOTZ FOUNDATION FOR THE ADVANCEMENT OF SCIENTIFIC INVESTIGATION

During the third year of the Ella Sachs Plotz Foundation for the Advancement of Scientific Investigation thirty-eight applications for grants were received by the trustees. Fourteen of these came from eight different countries in Europe and Asia, and the others came from the United States. The total number of grants made was thirteen, two of these being to investigators to whom aid had been promised for two and three years respectively. Seven of the new grants were made to scientists in countries outside of the United States.

In the three years of its existence thirty-five grants have been made, and investigators have been assisted in the United States, Great Britain, France, Germany, Austria, Hungary, Switzerland and Esthonia. The list of investigators and of the researches which have been aided in the current year is as follows:

Dr. L. H. Newburgh, University of Michigan, $1,250 a year for three years for a study of the production of chronic nephritis with high protein diets and amino acids.

Dr. William deB. MacNider, University of North Carolina, $1,700 a year for two years for research in chronic experimental nephritis.

Dr. Henry G. Barbour and Dr. Glenn R. Spurling, University of Louisville, $500 for investigation of operative and anesthetic shock.

Dr. Robert Chambers, Cornell University, $500 for the continuation of the study of problems in cell physiology.

Dr. James E. Dawson, Edinburgh, Scotland, $250 a year for two years, for investigation on the pathology of the breast.

Dr. Paul Hari, Budapest, Hungary, $1,000 for study of diseases of the metabolism with special reference to diabetes in animals and man.

Dr. Warfield T. Longcope, Johns Hopkins Hospital, $750 for studies upon the etiological relationship of streptococcus infections to acute and subacute nephritis.

Dr. David Marine, Montefiore Hospital for Chronic Diseases, $1,200 for study of the inorganic salts of the body and their excretion following suprarenalectomy.

Dr. J. K. Parnas, University of Lwow, Lwow, Poland, $500 for study of ammonia in blood.

Dr. Charles Richet, Paris, France, $1,000 for research on tuberculosis.

Dr. Paul Saxl, Vienna, Austria, $250 for research in immunity from infectious diseases.

Prof. Dr. Schlayer, Berlin, Germany, $250 for studies on renal function and its relation to blood and tissue.

Prof. H. Siegmund, Koln-Lindenthal, Germany, $250 for studies on the relation of antibody formation to the reticuloendothelial system.

Applications for grants to be held during the year 1927–28 should be in the hands of the executive committee before May 15, and should be sent to the secretary, Dr. Francis W. Peabody, Boston City Hospital, Boston, Massachusetts.

SCIENTIFIC NOTES AND NEWS

Dr. Ira Remsen, professor-emeritus of chemistry and president-emeritus of the Johns Hopkins University, died on March 4, aged eighty-one years.

The degree of doctor of medicine, *honoris causa*, was conferred upon Dr. John J. Abel, professor of pharmacology at the Johns Hopkins University, by a vote on November 4, 1926, of the faculty of medicine and academic senate of the John Casimir University of Lwow, Poland.

Dr. Hubert Lyman Clark, curator of echinoderms in the Museum of Comparative Zoology, Harvard University, and professor of biology at Olivet College from 1899 to 1905, delivered the Founders' Day address at Olivet College on February 24, the eighty-third anniversary of the founding of the institution. At the close of the ceremonies the honorary degree of doctor of science was conferred upon Dr. Clark.

The president and Council of the Royal Society decided at their meeting on February 17 to recommend for election into the society the following 15 candidates: Professor Edward Victor Appleton, Professor Thomas Graham Brown, Mr. Richard Higgins Burne, Dr. James Chadwick, Dr. Gordon Miller Bourne Dobson, Dr. Sebastian Ziani de Ferranti, Professor James Kendall, Professor Patrick Playfair Laidlaw, Professor Abercrombie Anstruther Lawson, Dr. Joseph William Mellor, Mr. Otto Rosenheim, Professor Meghnad Saha, Professor John Sebastian Bach Stopford, Dr. Herbert Henry Thomas and Mr. Charles Morley Wenyon.

D. W. Brunton, mining engineer of Denver, has been awarded the Saunders medal of the American Institute of Mining and Metallurgical Engineers in recognition of his contributions to engineering. On January 7 Mr. Brunton was given a dinner in Denver which was attended by more than two hundred engineers.

Portraits of Dean Frederick E. Turneaure and the late Professor Storm Bull were presented to the College of Engineering of the University of Wisconsin

during the recent convention of the Engineering Society of Wisconsin.

DR. CHARLES EUGENE GUYE, professor of physics at the University of Geneva, has been elected a member of the Paris Academy of Sciences.

DR. KARL GRAEBE, formerly professor of chemistry at the University of Frankfurt, recently celebrated his eighty-sixth birthday.

AT the annual general meeting of the Royal Astronomical Society, held on February 11, the Reverend T. E. R. Phillips was elected president.

DR. J. A. MURRAY was elected president of the Royal Microscopical Society at a meeting held on January 19.

AT the recent meeting of the National Malaria Committee, Atlanta, Ga., Dr. L. O. Howard, chief of the bureau of entomology, U. S. Department of Agriculture, was elected *honorary chairman;* Dr. Victor G. Heiser, New York, *chairman;* Dr. Felix J. Underwood, state health officer, Mississippi, *vice-chairman,* and Dr. L. D. Fricks, U. S. Public Health Service, *secretary.* It was decided to appoint a committee to raise funds to carry on research work and to standardize the procedure of malaria surveys.

DR. GEORGE A. BAITSELL, associate professor of biology at Yale University, has been elected a member of the executive committee of the Sigma Xi society for a term of five years.

GEORGE E. ROBERTS, vice-president of the National City Bank, has been elected a member at large of the Engineering Foundation to succeed Elmer A. Sperry, gyroscope inventor.

DR. FREDERICK H. DIETERICH, formerly instructor in pathology in Columbia University, has been appointed director of laboratories at the Good Samaritan Hospital, Cincinnati.

ANITA W. WENGOROVIUS, a graduate of Wellesley College, has been appointed as docent at the Peabody Museum of Natural History, Yale University, to succeed Eleanore W. Parmelee.

RUDOLPH MACY, formerly assistant professor of chemistry at the University of Maine, has joined the Chemical Warfare Service at Edgewood Arsenal, Md.

AMONG those who will conduct courses in the summer school at the University of Michigan this year are: Dr. Hugo Randolph Kruyt, professor of chemistry at the University of Utrecht; Dr. Edward Arthur Milne, professor of applied mathematics at the University of Manchester; Dr. Una Fielding, of the department of anatomy at the University of London; Professor William W. Cort, of the school of hygiene and public health at the Johns Hopkins University; Dr. K. F. Mather, associate professor of physiography at Harvard University, and Professor Charles W. Waters, of the department of botany at the University of Minnesota.

DR. IVAN C. HALL, head of the department of bacteriology and public health in the University of Colorado Medical School, will give the course in general bacteriology in the University of Chicago during the summer session of 1927.

DR. T. WAYLAND VAUGHAN, director of the Scripps Institution of Oceanography at La Jolla, returned in February from the third Pan-Pacific Science Congress held in Japan. He was appointed chairman of an international committee on oceanographic study of the Pacific.

DR. N. L. BRITTON, director-in-chief of the New York Botanical Garden, and Mrs. Britton, honorary curator of mosses, left for Porto Rico on January 20, expecting to devote two months to further botanical explorations of that island.

W. L. MCATEE, in charge of the division of food habits research of the U. S. Biological Survey, has been authorized by the secretary to go to Europe early in March to investigate the propagation of migratory waterfowl. He also plans to visit laboratories in Budapest, Hungary; Lednice, Czechoslovakia, and York, England, where investigations of the food habits of birds are being carried on.

IT is announced that Commander Richard E. Byrd, who flew in an airplane over the north pole, will attempt to fly across the south pole in the Antarctic summer of 1928. The flight base will be in the ice barrier around the pole. Bases of supplies will be established, facilities for taking off and alighting will be prepared and trial flights made in the next eighteen months. An American-built Fokker plane will be used, and the flight will be privately financed.

ANNOUNCEMENT has been made from Yale University that the lectures under the Silliman Foundation will be given by Ernest Clayton Andrews, government geologist of New South Wales, on "The Geology of the Pacific Area," and the lectures in the William Earl Dodge course on "The Responsibilities of Citizenship" by Sir George Newman, chief medical officer of the British Ministry of Health. Dr. William Brown, Wilde reader in mental philosophy at Oxford University and lecturer in psychotherapy in the University of London, gave the Dwight H. Terry lectures at the university on March 10 and 11.

THE sixth Sedgwick memorial lecture will be given at the Massachusetts Institute of Technology on the

afternoon of April 8 by Dr. Haven Emerson, professor of public health administration in Columbia University. Dr. Emerson will talk on "Public Health Diagnosis" and will consider the origin and present development of diagnostic methods applicable to communities seeking better health.

Professor Hans Driesch, for the past semester Carl Schurz professor at the University of Wisconsin, delivered the Mendel lecture at Holy Cross College on February 26 on "The Philosophy of Organisms."

Professor E. Schrödinger, of the University of Zurich, delivered three lectures at the University of Iowa to graduate students in the departments of physics and mathematics on February 9 and 10. The lectures were entitled "The Undulatory Theory of Atomic Structure."

Dr. Cecil H. Desch, metallographist and physical chemist of Sheffield University, England, addressed a meeting of the Washington Academy of Sciences on March 4, speaking on "The Growth of Crystals."

Dr. J. H. Dellinger, senior physicist in the U. S. Bureau of Standards, lectured before the Franklin Institute on March 3, on "Directive Radio Transmission." On March 16, Dr. C. H. Kunsman, physicist in the fixed nitrogen research laboratory of the U. S. Bureau of Soils, will address the institute on the synthesis of ammonia.

Professor John C. Hemmeter lectured before the section of historical and cultural medicine, at the New York Academy of Medicine on February 24. On that occasion, for the first time, was exhibited his work, "Master Minds in Medicine."

Dr. Francis G. Benedict, director of the Carnegie Nutrition Laboratory, Boston, addressed a meeting of the Harvard Medical Society on March 1 when he spoke on "The Production and Loss of Heat in the Human Body."

Professor T. T. Quirke, chairman of the department of geology of the University of Illinois, delivered a series of lectures before the geology staff and graduate students at the University of Iowa on February 21, 22 and 23.

Dr. B. S. Butler, of the U. S. Geological Survey, lectured to the students of the Colorado School of Mines on February 17, on the subject of "The Origin of Ore Deposits with particular reference to the Ore Deposits of Utah." The lecture was presented under the auspices of the local chapter of Sigma Gamma Epsilon.

Dr. Joseph T. Singewald, Jr., professor of economic geology at the Johns Hopkins University, gave two lectures before the school of geology at the University of Virginia on March 2, on "The Geology of the Andes of Central Peru" and "Geological Explorations in the Upper Amazon Basin."

Dr. Edgar James Swift, head of the department of psychology at Washington University, will lecture before the students and officers of the postgraduate school of the United States Naval Academy at Annapolis on March 26. The subject of the address will be "The Psychology of Influencing and Directing Men."

The annual dinner commemorating the birthday of Sir Francis Galton, the first president of the British Eugenics Society, was held by the society on February 16 with Major Leonard Darwin, president, in the chair. Dr. A. F. Tredgold delivered the Galton lecture on "Mental Disorder in Relation to Eugenics."

Dr. Albert W. Smith, professor of chemistry and head of the department of chemical engineering at the Case School of Applied Science, has died, aged sixty-four years.

Dr. Ludwig Radlkofer, formerly professor of botany at Munich, and director of the botanical museum, has died, aged ninety-eight years.

The meeting of the American Institute of Chemists will take place at Yale University on March 28, under the presidency of Dr. Treat B. Johnson, professor of organic chemistry at Yale University. An announcement of the meeting was printed in the last issue of Science, in which it was incorrectly intimated that the meeting had taken place earlier in the month.

The thirty-seventh annual meeting of the Ohio Academy of Science will be held on April 15 and 16, at the Ohio State University. The time and place will make it possible for those in attendance to hear Dr. R. A. Millikan, of the California Institute of Technology, in a series of four or five lectures, and also to hear Dr. J. H. McGregor, of Columbia University, on the "Prehistoric Races of Man" on April 14 at 8:00 o'clock. The lecture by Dr. McGregor is under the auspices of the Omega chapter of the society of the Sigma Xi. On March 1, Dr. E. M. East, of Harvard University, gave a lecture at the university on "The Biology of the Immigration Policy."

The non-biological science section of the Ohio Educational Conference which is to be held on April 8, under the auspices of the college of education of the Ohio State University, includes seven scientific papers, among them addresses by Professor Dayton C. Miller and Professor B. S. Hopkins.

The forthcoming annual meeting of the American Association of Museums is to be held from May 23

to 25 in Washington, D. C., not in Chicago as originally planned.

ACCORDING to the *Geographical Journal* the second congress of Slav Geographers and Ethnologists will be held this year in Poland between June 1 and 11. Visitors from other countries will be admitted to take part in it. The meetings will take place at Warsaw and five other Polish cities in turn, and two special trains will be at the disposal of the members, in which it is proposed to make a tour through a considerable part of the country. The president is Professor E. Romer, and the secretary, Professor L. Sawicki, the officers of the organizing committee being at 64 Gradzka, Cracow.

A SERIES of free public lectures will be given at the New York Botanical Garden during March and April. These lectures will be given at 3:30 on Sunday afternoons as follows: March 5, "Garden Soils and Fertilizers," Mr. J. G. Curtis; March 12, "Floral Features of Florida," Dr. J. H. Barnhart; March 19, "Through the Western Andes of Colombia," Dr. Francis W. Pennell; March 26, "The Natural Bridges and Desert Flora of Southeastern Utah," Dr. P. A. Rydberg; April 2, "The State Park at Devil's Lake, Wisconsin," Dr. A. B. Stout; April 9, "With Burroughs and Muir in the Southwest," Dr. Clara Barrus; April 16, "Coffee: The Plant and the Beverage," Dr. Ralph H. Cheney; April 23, "The Tea Gardens of Ceylon and Japan," Dr. H. A. Gleason; April 30, "Children's Gardens," Miss Ellen Eddy Shaw.

THE new laboratory of physics at Columbia University, constructed at a cost of $1,500,000, was formally opened on February 25. The occasion was marked by a dinner in the Faculty Club, on Morningside Avenue, at which Professor Michael I. Pupin, of the department of electromechanics, was toastmaster. The dinner was attended by present and former members of the staff of the department of physics, trustees and representatives of all scientific departments and members of the Optical Society of America and the American Physical Societies then meeting at the laboratory. Dean George B. Pegram, of the schools of mines, engineering and chemistry, spoke in behalf of the department of physics. Samuel R. Williams, professor of physics in Amherst College, spoke for the Ph.D. alumni. Ernest Merritt, professor of physics at Cornell University, responded for other universities, and Dr. Frank B. Jewett, president of the Bell Telephone Laboratories, responded for the industrial research laboratories.

THE anti-evolution bill introduced in the North Dakota legislature on February 8 has been killed in committee without a dissenting vote.

MISS ELEONORE WUNDT writes that she would like to receive letters addressed by her distinguished father, Professor Wilhelm Wundt, to American psychologists for use in the biography that she is preparing. Any such letters will be copied by her and promptly returned. They should be sent to Bismarckstr. 31, III, Jena, Germany.

STANFORD UNIVERSITY has dropped its proposed $1,000,000 Luther Burbank foundation fund to perpetuate the experimental work at Santa Rosa and Sebastopol.

THE University of Michigan observatory, under construction at Bloemfontein, South Africa, will be completed through the generosity of Robert Patterson Lamont, of Chicago, who has also donated the Lamont telescope which will be installed in the observatory. The recent donation of $25,000 will be used for the construction of the observatory.

THROUGH the courtesy of Professor Rudolf Florin, of the National Museum of Stockholm, Sweden, the New York Botanical Garden recently received a shipment of about fifty specimens, including forty-two different species of Triassic and Jurassic fossil plants, representing collections from a number of localities in widely separated parts of the world—Brazil, Antarctica, Spitzbergen, Japan, England, Austria, Bavaria and Scandinavia.

THE American Home Economics Association, through the trustees of the Ellen H. Richards memorial fund, announces the offer of a graduate fellowship of $500 for the year 1927–28. Applications should be made in writing on or before April 1, 1927. Full information may be obtained from the office of the American Home Economics Association, Washington, D. C.

THE question of organizing a professional division of mechanics and physics and applied mathematics is being considered by a group of members of the American Society of Mechanical Engineers who met during the 1926 annual meeting. This section would embrace analytical mechanics as applied to rigid, elastic and fluid bodies, including (a) mechanics of materials, (b) kinematics and dynamics of machines, (c) stresses in structures and machines and (d) friction and lubrication; physics, including (a) heat flow, (b) thermodynamics, (c) acoustic and noise problems; and applied mathematics. The following committee was appointed to formulate a definite plan for the division: *Chairman,* Dr. S. Timoshenko; *secretary,* A. L. Kimball; H. A. S. Howarth.

PRESIDENT COOLIDGE has approved a request for $50,000 for the continuation of research work being conducted by the North Central Station of the United

States Bureau of Mines in cooperation with the University of Minnesota Experiment Station and School of Mines. The sum will be used to investigate processes for producing high-grade manganese alloys from low-grade ores, which occur abundantly in Minnesota.

ACCORDING to the Experiment Station *Record*, the Peruvian Agricultural Institute of Parasitology has recently been organized by the National Agricultural Society of Peru to study the insect pests and fungus diseases which affect the crops of the coastal region, especially cotton and sugar cane. Dr. C. H. T. Townsend has been appointed in charge of this institute and is engaged in the selection of a site and the erection of the necessary buildings. It is expected that one of the earliest studies will be made of the cane borer, said to be the only insect which seriously damages sugar cane in Peru.

THE Belgium correspondent of the *Journal* of the American Medical Association writes that the Academy of Medicine has appointed a committee to make arrangements for the commemoration of the life and works of Dr. Paul Heger. The committee plans the publication of a memorial volume in his honor. In addition, it announces that a special fund will be created and placed at the disposal of the occupant of the chair of physiology at the University of Brussels, with a view to rendering personal aid to investigators or to make possible the carrying out of researches that are difficult under present economic conditions.

THE *Journal* of the American Medical Association states that the senate committee on foreign relations has approved a bill introduced by Senator Wadsworth, New York, providing for the erection and maintenance of the Gorgas Memorial Laboratory in Panama, to be paid for in part by the United States to the extent of an annual expenditure of $50,000. The bill contemplates that South and Central American governments will contribute annually for the maintenance of the laboratory, and that the government of the United States shall be represented on the board or council directing the administration of the laboratory.

A MEETING was recently held in the office of Dr. Charles Campbell, deputy minister of mines, to discuss with representatives of the United States Bureau of Mines methods of cooperation among the bureau and department of mines and the National Research Council of Canada. The work of the United States bureau was outlined by Dr. Dorsey Lyon, chief metallurgist and supervisor of experiment stations, and his assistant, B. C. Ralston; that of the Dominion Department by John McLeish, director of the mines branch, and members of his staff, and that of the research council by J. M. Morrow and F. E. Lathe. Definite arrangements were made for the close cooperation of the two governments in carrying out investigations on all the subjects discussed, similar to that now existing between the United States Bureau of Mines and the British government on fuel research.

THE Experiment Station *Record* states that arrangements are being completed to open a rabbit experimental station at Ontario, Calif., on the grounds of the Chaffee Union High School. The use of a tract of 5 acres of land with the necessary fencing and water is to be given the U. S. Department of Agriculture for the purpose, and it is expected that $15,000 will be raised by the National Rabbit Federation to erect the necessary buildings and other improvements and provide the running expenses for at least one year. The purposes of the station will be the study of the economic production of rabbits for meat and fur, breeding and feeding methods, diseases and parasites, and the utilization of rabbit offal and manure as fertilizer. It is hoped to open the station in March with D. Monroe Green of the U. S. Biological Survey in charge.

A CORRESPONDENT writes that Miss Dorothy Garrod, of Oxford University, whose discovery at Gibraltar of the cranium of a child belonging to the Neandertal race was reported at the Oxford meeting of the British Association for the Advancement of Science last August, has now discovered the lower jaw of the same individual and also an additional portion of the cranium. In France, D. Peyrony, of Les Eyzies, has discovered at the type station of La Madeleine (Dordogne) the sepulture of a child. He states that the body had been richly decorated at the time of burial. It belongs to the Magdalenian Epoch, which is the last stage of the Paleolithic Period.

UNIVERSITY AND EDUCATIONAL NOTES

THE campaign conducted by the Johns Hopkins University half-century committee for endowment funds for the university and the hospital, closing December 31, 1926, resulted in total contributions of $7,022,019 from 3,992 subscriptions.

FUNDS for the further development of the University of Pennsylvania's medical facilities have reached the $1,235,000 mark with the receipt of new gifts amounting to more than $135,000. A total of $3,050,000 is sought.

GIFTS totaling more than $365,000 were accepted for the University of Michigan by the Board of Regents at the February meeting. These included $225,000, to be paid in amounts of $45,000 a year for five years, from three anonymous donors, to establish a laboratory for research and investigation of cancer and other forms of growth.

BY the will of the late George French Porter, of

Chicago, the University of Chicago is to receive $200,000, the Field Museum and Yale Uniersity $25,000 each.

DR. WILLIAM MATHER LEWIS has resigned the presidency of George Washington University to become president of Lafayette College, at Easton, Pa.

DR. B. M. DUGGAR, of the Missouri Botanical Garden and Washington University, St. Louis, has been appointed professor of applied and physiological botany at the University of Wisconsin. Dr. Duggar will take up his residence at Wisconsin in September.

DR. SAMUEL R. DETWILER, associate professor of anatomy at Harvard University, and Dr. Philip E. Smith, associate professor of anatomy at Stanford University, have been appointed professors of anatomy in the College of Physicians and Surgeons of Columbia University.

DR. FRANK E. BURCH, St. Paul, has been appointed head of the eye, ear, nose and throat department, University of Minnesota School of Medicine, to succeed the late Dr. William R. Murray.

HOWARD O. TRIEBOLD, formerly holder of the American Cracker Manufacturers fellowship under the direction of Dr. C. H. Bailey, in the division of agricultural biochemistry at the University of Minnesota, has been appointed instructor in the chemistry of milling and baking in the department of agricultural and biological chemistry at the Pennsylvania State College.

DISCUSSION AND CORRESPONDENCE

THE INCREASE IN SCIENTIFIC PERIODICALS SINCE THE GREAT WAR

IN looking back to the period of the great war, it seems for the most part like a nightmare, but there were some bright spots, one of these being the peacefulness in the field of publication of scientific serials. Many journals took a vacation, some slowed up publication by dropping out or combining numbers, others ceased altogether. Even in 1919 when the war was supposed to be over, the amount of such material coming into the library of the Department of Agriculture was so small, that one person could look over the current mail and make all the necessary cards from which the "Botany, current literature" lists were compiled; and there was still plenty of time for other matters. Now in 1926 the indexing for the list consumes practically all the time of one person and a large part of the time of a second, and as for review and abstract journals, they are a task in themselves.

The growth in size of the "Botany, current literature" lists may, I think, be fairly taken as a measure of the increase of publication in that particular field using that phrase to include scientific serials containing botanical material. In 1919 when the issuing of the lists began, the average size was eight to nine pages, fourteen pages being an unusually large list. In 1924–25 the average was twenty-two pages and with the shorter page now in use, it runs to thirty-three pages. Such an increase in publication would hardly have been looked for as a result of the war, in fact one would have expected quite the contrary. Some journals have changed name or form, and there are of course some casualties, but new recruits have, I think, more than filled up the ranks.

When I look over the mail that comes into the Department of Agriculture library each day, in its motley array of languages, I begin to doubt the wisdom of the principle of self-determination and almost to wish that the war had left the map of Europe as it found it. There are not only new publications from the older countries, but all these newly established states are plunging into publication, seemingly in all fields of science and what is more appalling to the indexer, each in its own language. Sometimes they are considerate enough to publish summaries in some of the well-known languages, as German, French or English, but just as often they do not. Translators are not available and dictionaries are woefully inadequate, particularly for the scientific terms. Some one has asked how we manage with these unfamiliar languages. One method used reminds me of a story. A small colored girl was being taught to read by means of a picture primer, her teacher placing her hand over the picture, pointed to a word and asked, "What is that, Sally?" Quick as a wink Sally replied "Ox." The teacher was suspicious as Sally had been rather slow in the uptake. "How do you know it's ox, Sally?" she asked. "Seed its tail," was the reply. That is often the method one has to pursue, one translates the title as best one may, looks over the text for old friends, rusts, smuts, weed flora, and familiar names of plants or sometimes familiar scientific terms taken over bodily from some better known language and decides that it belongs in the botanical catalogue and therefore in the "Botany: current literature" list. Every day one gives thanks for Latin. If it were not for the Latin scientific names and Latin descriptions, where would one be? As a listener at the discussion on nomenclature at the International Conference of Plant Science at Ithaca, I felt like protesting against the recommendation to give up the requiring of Latin in descriptions of new species, for, in many cases, the Latin is the only lifesaver one has in this flood of foreign languages. Do not encourage them to describe their plants in Russian, Czecho-Slovakian, Bulgarian, etc.!

In looking over the list of scientific serial publications indexed for "Botany: current literature," I find

that beginning with 1920 there are one hundred and fifty new titles of publications in sixteen different languages, twenty-three of these are Russian and eight Czecho-Slovakian. The activity of a country like Russia is astonishing when we consider through what an upheaval it has been and how hard have been the days of its reconstruction. One wonders how scientists have been able to work and publish under such conditions. In my impressions as to the amount of publications from Russia I am borne out by Miss Katherin G. Upton, who handles the Russian material for the library. These come not only from Russia proper but from Siberia, Central Asia, Turkestan, White Russia, Caucasus and Ukraine. The Botanic Garden at Leningrad besides continuing to publish the *Acta Horti Petropolitani, Bulletin and Bolezni rastenii* (its journal of plant pathology) has begun two new publications, the "Notulae systematicae" from its Herbarium and "Notulae systematicae" from the Cryptogamic Institute. When I mentioned the large number of publications coming out of Russia to Mme. Haffkin-Hamburger, the Russian delegate to the American Library Association Conference held at Atlantic City in October, her modest reply was "But we are so pig (big)." But their bigness, another handicap taken in connection with other conditions, makes the fact the more surprising.

Then one has to consider the publications which we have not been able to get hold of which are of interest to the indexer of botanical literature. There are some fourteen of these which have been announced in various review journals.

If the increase of publications is to continue what is to become of the maker of catalogues and lists such as the "Botany: current literature"? Shall we be swamped and have to give up entirely, or can we work out some selective method which will yet be satisfactory to the omnivorous user of such catalogues and lists?

We have heard much recently of the necessity of Americans becoming more internationally minded. I should suggest as one means to that, the indexing of foreign scientific publications.

Alice C. Atwood

Bureau of Plant Industry,
Washington, D. C.

HOOKE'S LAW AGAIN

A careful reading of Dr. Paul E. Klopsteg's rejoinder[1] fails to show me the need of modifying my statement that the instruction sheet referred to "conveys the impression that accurate measurements should show strict proportionality between strain and stress." In fact my claim is virtually admitted in Dr. Klopsteg's own statement, "This graph, which is a straight line, shows that the elongation is, *within the limits of experimental error,* proportional to the stretching force."

It may be that my view of laboratory instruction is "unusual," but I hold that laboratory instruction should instruct and not tolerate inaccurate information. Science demands truthful statements. A scientific statement that is nearly true is about as valuable as an egg that is nearly good. I accept the opinion that my objection "must for the sake of consistency apply also to the measurement of acceleration of gravity by means of the simple pendulum." Yes, let the instructor warn the student that the vibrations are not isochronous and that the obedience of gases to Boyle's law is about as perfect as the obedience of our citizens to the Volstead law.

It is fairly obvious that if the tested wire is taken from a spool the initial increment of length when a stretching force is applied is partly an elastic lengthening and partly a result of straightening the wire. This latter effect *diminishes* with increasing loads while the elastic lengthenings produced by equal increments of load *increase,* as I have demonstrated. The net result is that the lengthenings are very nearly proportional to the forces. This is not mere hypothesis, this I have observed.

Since some may think that all my measurements were made with fine wires, I quote the following from my original paper:

> In order to be perfectly sure that the phenomena which I have described were not confined to fine wires, I made careful measurements with larger wires. The loads placed on these were gradually increased to a maximum of 18 kg and without exception the results obtained were similar to those which I have reported. The reasons, however, why I preferred to use fine wires are first, because in these the thermal effects vanish more rapidly, and second, because the loading and unloading can be done in shorter time, and thus the after-effect is more completely eliminated.

The measurements with a steel wire will be found in my original paper and are similar to those made with brass and copper. Iron told the same story. Since the figures with brass and copper with diminishing load are interesting I give here the ratio of elastic lengthening in mm to load in kg in the case of a brass wire .66 mm in diameter:

kg	Ratio	kg	Ratio
10	6.135	5	6.050
9	6.121	4	6.033
8	6.106	3	6.023
7	6.084	2	6.015
6	6.065	1	6.010

[1] Science, November 5, 1926, p. 449.

The load had previously been increased from 0 to 10 kg with similar results.

Although Dr. Klopsteg expresses the belief that the apparatus for which the instruction sheet was written "would fall far short of sufficient precision to show the lack of proportionality," I find it is capable of giving results similar to mine. For, using the data of the first half of set number 2 of measurements made under laboratory conditions and given on page 8 of the instruction paper, I get the following ratios of strain to stress as the load increased from 1 to 10 kg. Since there is evidence that the load of 1 kg was needed to make the wire straight 14.7 was taken as the zero reading.

Added load in kg	Ratio	Added load in kg	Ratio
1	6.50	6	6.63
2	6.60	7	6.63
3	6.60	8	6.638
4	6.60	9	6.644
5	6.62		

It is gratifying to see the apparatus argue on my side.

It is quite true that at present the champions of Hooke's law are "in good company," but let us not forget that we are here concerned with a question of fact, and that those men are in the *best* of company on whose side the facts are arrayed.

Joseph O. Thompson

Amherst College

SEYMOUR SEWELL ON "SALPS OF INDIAN SEAS"

In this careful paper, which treats all but six of the recognized species, two errors of nomenclature made (and later corrected[1]) by Metcalf[2] are perpetuated, two wrong subgeneric names, *Apsteinia* (instead of *Ihlea*) and *Ritteria* (instead of *Ritteriella*), being used. As Professor Cockerell pointed out to me, *Apsteinia* and *Ritteria* were preempted for other groups, so I withdrew them and substituted other names, as above. My Science paper evidently did not reach Sewell's hands.

Sewell describes, but does not name, a clearly distinct form of *Salpa* (*Cyclosalpa*) *pinnata*, showing resemblance in its musculature to *pinnata* but in the aperture of its ciliated funnel being much simpler even than *pinnata* subspecies *polae* though not so simple as *affinis*. I would recognize Sewell's form as a subspecies, the subgenus *Cyclosalpa* including thus *pinnata* (Forskal), *pinnata polae* (Sigl), *C. pinnata sewelli*, *affinis* (Chamisso), *floridana* (Apstein), *bakeri* (Ritter) and *virgula* (Vogt).

Maynard M. Metcalf

The Johns Hopkins University

[1] Metcalf and Bell upon Salphidae: Science n. s. Vol. 6, No. 1278.

[2] Metcalf and Bell. "The Salpidae: A Taxonomic Study." U. S. National Museum Bulletin 100, Vol. 2, part 2.

STORM DAMAGE AT LONG BEACH, N. Y.

The unusually severe storm of Sunday, February 22, furnished a striking example of the value of well-constructed beach protective devices. The shore at Long Beach is protected for the greater part of its length by a series of fairly heavy wooden groins extending into the ocean at right angles to the shoreline; the landward ends of these groins are not tied to bulkheads, as is usually the case, but are extended into the slightly higher sand bank at the rear of the beach. On a short unprotected portion of the beach the waves undermined twelve or fifteen houses, which toppled forward on their faces and then frequently collapsed. No houses were destroyed on any portion of the shore protected by groins, so far as visited by the writer.

In a number of places the groins themselves were partially or completely destroyed by the pounding of the waves, but apparently had borne the brunt of the attack long enough to save the buildings under their protection. The destruction of the groins seemed to be due in some cases to the removal of sand from around their bottoms, whereupon they were floated by their own buoyancy often swinging around nearly parallel to the beach in such a position that the waves soon tore the floating part from the still firmly imbedded portion. In other cases it seemed that they were too weak to withstand the smashing onslaught of the waves, and were broken off like toothpicks. The frequent destruction of timber groins at Long Beach and elsewhere along the Atlantic coast causes doubt as to the advisability of using anything but the heaviest riprap for structures exposed to storm waves from the open ocean.

In one or two places on the western portion of the beach erosion had already started around the landward ends of the groins, and had cut a considerable channel. Fortunately no buildings were situated right at the ends of these groins, or an excellent example of the danger of omitting bulkheads would have been afforded. Due to the danger of such erosion around the inner ends of groins, it is usually unsafe to use them alone unless they can be extended so far into the shore that no apprehension need be felt about scouring around their ends under the combined attack of an unusually high tide and a severe storm. Tight

bulkheads stop this erosion at a level fairly even with their tops, and in conjunction with groins are believed to provide the most efficient protection.

The whole problem of beach protection is so influenced by financial considerations that although it is generally possible to predict what structures will best preserve a given beach, it is often impossible to adopt them, because of the cost which may be prohibitive to a small community. In such cases a cheaper substitute must be used. At Long Beach more expensive structures might have obtained better results, but those erected performed valiant service in cutting down the destruction to a minimum.

Henry S. Sharp

Columbia University

SCIENTIFIC BOOKS

A HISTORY OF OUR TIMES[1]

It has been suggested that the universities should establish a new series of courses, dealing with the additions to human knowledge and experience within the past decade or twenty years. Such a plan, if fully and adequately developed, would serve the needs of innumerable busy people who wish to keep in touch with at least certain aspects of the progress of the world. To some extent the universities already minister to such needs, especially in their summer schools and extension divisions. But after all, comparatively few can take advantage of what is offered, and there is no comprehensive organization of the whole field of modern knowledge in any school.

What the schools have not done, and perhaps can not do, has been attempted by the editor and staff of the Encyclopaedia Britannica. The volumes before us purport to describe what has been significant in human affairs during the last fifteen years. Not only material events, but also the stuff that dreams are made of: those aspirations of the mind, vague or well defined, which motivate our lives. In this gigantic undertaking the editor has certain advantages over even the largest university. He can command a faculty so eminent that it represents on the whole the present competence of our species. Instead of requiring attendance in the classroom, he sends his message to the people of the world, and the most isolated student may have it all at his service. He offers a mirror to mankind, reflecting good and evil, success and failure, hope and despair. We have toiled and struggled, these fifteen years; what has it all amounted to? Well, here it is: let each man sit in judgment on himself and his kind.

[1] The Encyclopaedia Britannica. The Three New Supplementary Volumes. London and New York. 1926.

Surely the educational consequences must be very great. Whatever faults may be found, and they are doubtless many, it must be said that a vast mass of essentially accurate information is made the common property of all peoples. That, at least, ought to make for better understanding and more willing cooperation. It is perfectly true that in the perspective of time present values will be strangely altered. Posterity will criticize our judgment of many things. But judge we must, and whatever imparts wisdom to this judgment is worth our earnest attention.

It is not very difficult to discern wherein the present volumes will appear ill-proportioned to later generations. They really constitute a sort of newspaper *in excelsis*, a summary of what may be expected to interest the readers. Hereafter it will be said of many matters that they were properly subjects of popular concern at the time, but their significance was mainly ephemeral. Of others it will be said that they never deserved the attention they received. In his prefatory note the editor states that one of his main purposes has been "to escape from the passions and prejudices and shattering discords of the war period—to revive and enhance that intellectual cooperation between distinguished authorities of every nation, that civilized community in the sphere of intellect, which the war temporarily destroyed, but which throughout the century before 1914 it was the increasing object of the Encyclopaedia Britannica to nourish." Nevertheless, in looking through the volumes, one is struck by the inordinate space given to the various details of the war, and to methods of warfare. Such titles as "Victory, Advance to" and "Western Front" are intelligible only because recent events dominate our minds. Probably this excessive dominance of the war motive and war interest will be distasteful to a large number of readers, and yet it may be defended on the ground that it has to do with the prime concern of a large part of the civilized world during the period under review. As a contribution to history, it is of great value to have the events of the war accurately described as they could not be during the conflict. Not only are the facts now given with reasonable completeness, but the temper of the articles is fair and well considered. It may well be that the principal effect will be to create, not a warlike spirit, but a sense of humiliation and disgust that such things should have been possible. The personal biographies also depart widely from encyclopaedic standards, and stand rather on a journalistic basis. There are detailed accounts of many politicians, moving picture actors, and the like, who will be quite forgotten after a few years. Thus Mary Pickford gets three inches of space, Fabre only an inch and a half. This is not

e to the existence of a biography of Fabre in a evious volume, although there had been references his work. Posterity will see by these notices herein our interests lay, only of course the actual blic interest in and knowledge of Mary Pickford compared with Fabre is very much greater than e proportions cited might suggest.

To the reviewer it seems that when we consider the esentation of science and art in the volumes, the traordinary progress and development of science ntrasts strangely with what appears to be an actual generation of the arts. If it is said that this opin- n has no basis, as coming from one unskilled in the ts, I venture to maintain that even a scientific man s a right to criticize artistic productions. Both ience and art seek to interpret nature. Scientific orkers, in spite of many errors, approach ever earer to the understanding of reality, not merely of aterial objects but of mental processes. When we rn to the article Sculpture, and see anatomically correct figures seriously presented as offerings of e dominant modern schools, we surely have the ght to ask, what is the matter with the mentality of ose who see the human body in this distorted form, d actually prefer ugliness to beauty? If the mod- nist in art then claims that the idea of beauty anges, and is purely subjective, we reply that to us ere is also an objective standard of beauty, ex- ressed in the perfection of a type according to its rm and function. It is this response to objective ality, this harmony with nature, which seems to us be the test of sanity. Turn again to the article Stage and Stage Production"; it is illustrated by a lored plate which merely exhibits the sloppy eccen- icity of a certain school of painters. Fortunately, actual stage setting ever could present such an ppearance to the human eye. So it is with some of e other arts, as any reader can find out for himself. n the contrary, the scientific articles, while tech- cal, amaze one by the revelation of progress and e achievements of the human mind. Is it not pos- ble, should it not be possible, to utilize these great owers in other directions with similar success? If , certainly not by following fads, but by long- ntinued and patient labor, for small material re- rds.

One other matter of editorial policy deserves discus- on. It has been the plan, again departing somewhat om traditional usage, to have the articles written by presentatives of the several topics or interests, re- rdless of whether we may be supposed to agree with eir opinions. The complexity of modern knowledge such that an editorial orthodoxy is hardly possible. onsequently, to the surprise of many, the article on enin is by his associate, Trotsky. It seems to me to be a very good article, giving an account of Lenin's activities to which no one should object. But when we come to the article on Mrs. Eddy, we wonder whether we shall be presently told that "the Encyclopaedia Britannica states" that "beyond cavil or question, her life was an illustration and a demonstration of her proposition that prayer, watching and working, combined with self-immolation, are God's gracious means of accomplishing whatever has been successfully done for the Christianization and health of mankind." The truth is, the Encyclopaedia is a platform in the ordinary, but not in the political sense; it is a place from which specialists give their opinions, but these opinions must not be considered to have any particular editorial sanction.

One result of this free—we had almost said irresponsible—editorial policy is a frequent relief from the ponderous gravity of the traditional encyclopaedia. Not that there is any unseemly levity, but writers appear to feel free to say what they think without the sense of compromising the universe. This imparts freshness and sincerity to many articles, making them very good reading.

It is out of the question to review many of the articles separately, but a few comments are possible. The great earthquake in Japan, misnamed "the Tokyo earthquake," as it was more severe in Yokohama, is not at all adequately discussed. In the account of Sir Charles Eliot, it is not mentioned that he is one of the leading authorities on nudibranchiate mollusca. Entomology is treated only in its economic and medical aspects, and zoology is confined to a consideration of the vertebrates, mainly fishes. Hardly any attention is given to the cultural aspects of natural history, or to the advancement of our knowledge of the out-of-doors. To this extent I think it must be said that the treatment of the biological sciences is seriously inadequate. The summary of biology (J. Arthur Thomson) is extremely good, remarkable equally for the breadth of treatment and the number of striking discoveries recorded. Evolution is by no less than six different representative authors. The section "Theory of Organic Evolution" (T. H. Morgan) is especially noteworthy for its concluding paragraphs on the relation between modern views and the opinions of Darwin. It was not possible for Darwin to make an analysis of the different types of variation and their consequences, as we can to-day. Some of his reasons for evolution no longer appear valid, but others have taken their place. "Thus what the theory of natural selection lost in one direction it gained in another, and the probability that evolution has taken place by the selection of chance variations is as great as at the time when Darwin advanced his theory of natural selection." Bateson on Genetics and J. Arthur

Thomson on Heredity are important and worthy of their distinguished authors. Household Appliances, well illustrated, shows what physical science and invention have done to make life easier and more convenient. India (several authors), Russia (Arthur Ransome) and the United States (several authors, but especially A. Bushnell Hart) appear to me to be among the greatest successes of the Encyclopaedia. I was disappointed in the article on Siberia, which does not even mention the American Expeditionary Forces, though these are cited in the article "Japan." "Immunity" (Sir A. E. Wright) is a very important and of course very modern article. The article on Indians, North American (C. H. Burke) shows that, contrary to a popular misconception, the Indians are increasing in this country. "Influenza" (S. L. Cummins) raises very interesting questions concerning the origin and nature of the germs causing pandemic outbreaks. "Intelligence Tests" (E. L. Thorndike) are discussed in an interesting but suitably cautious manner. Sir Arthur Keith gives a detailed account of what is known concerning the evolution of man, concluding with the suggestion that the study of hormones is very significant in this connection. "Mendelism" is by Bateson, as was most appropriate. "Paleontology," while excellently done, suffers from inadequacy in certain directions. Thus the author has never heard, apparently, of Tillyard's great discoveries among fossil insects, which throw so much light on the evolution of the various orders. The Pan-Pacific Union and the various Pan-Pacific meetings of recent years are overlooked, though certainly of international importance. We suspect that the article "Petrograd" does not do justice to that city, but hope to find out personally in the course of next summer. "Population" (A. M. Carr-Saunders) is full of significant statistics. "Protozoology" (C. Dobell) is very interestingly written, and deals with a rapidly advancing subject. "Relativity" (J. H. Jeans) and its "Philosophical Consequences" (Bertrand Russell) are explained as clearly as the nature of the subject permits. "To the relativist the essential background to the picture of the universe is not the varying agitation of a sea of aether in a three-dimensional space but a tangle of world lines in a four-dimensional space. Moreover, it is only the intersections of the world lines that are important. An intersection at a point in the continuum represents an event, while the part of a world line which is free from intersections represents the mere uneventful existence of a particle or a pulse of light." But as a writer recently urged in another case, when we have decided "what is it?" we should then ask "what of it?" Can ordinary people derive any pragmatic values from these considerations? This is the question which Bertrand Russell undertakes to answer.

He holds that, in time, the theory of relativity "may considerably modify the ordinary educated man's picture of the universe, possibly with far-reaching results." But when he assures us that the "space-time" frame of reality "is known only in its abstract mathematical properties; there is no reason to suppose it similar in intrinsic character to the spatial and temporal relations of our perceptions as known in experience," he is excluding it from the realm of practical truth. The four-dimensional, space-time conception makes no difference to our actual situation, or to our conduct, unless it menaces our sanity. It is a relief to turn from these abstractions to the delightful article on Sargent by Julie Helen Heyneman. It is a type of many sympathetic biographies in the volume; others are those of H. G. Wells and Bernard Shaw. "Sex," by Bateson, is a very valuable summary. "Tissue Culture" (Alexis Carrel) sets forth the extraordinary successes of this method, which is nevertheless said to be "still in its infancy."

Summing up our impressions, it may be said that the work has on the whole been admirably conceived and executed. While nearly every critical reader will see some things he wishes were different and some statements he believes to be erroneous, it is obvious that such imperfections could not well be avoided. It is a very great thing to have given so nearly true a picture of a period so filled with important events, so complex in the interrelations of these events. The general conception is on liberal lines, and we are not made to feel that there is any undue dominance of ancient prejudice or superstition, though there are undoubtedly large concessions to modern fashions. Even in scientific work, fashion is potent, and the important thing of to-day may not seem so important to-morrow. This is not without its advantages; thus the Mendelian fashion has certainly led to concerted investigations all over the world, and here and there more intensive, cooperative work with results of the highest importance. Yet there are different aspects of biological science waiting to have their innings, and some day these will occupy the field. No doubt the Encyclopaedia will have a large part in fostering a broader interest, in enabling us to see the wood as well as the trees, and this in itself is a very conspicuous service. Yet its elaborate analysis clearly invites synthesis, and it may be that some genius will weave the essence of it all into a great epic having universal appeal. Whether this is possible or not, we may at least conclude by hoping that the success of the undertaking will be so great that the publishers will feel justified in issuing such volumes at intervals of fifteen to twenty-five years indefinitely, thus taking stock of man's business in this world.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

QUICK METHOD OF PRESERVING CATS FOR DISSECTION

THE customary techniques for preserving cats for dent dissection are by embalming or by injection formalin through the femoral or carotid arteries. l these require a certain amount of dexterity and nsiderable time, especially as the best results are tained with anesthetized specimens or by using avity pressure. It is probable that analogy with e medical school dissecting-room is responsible for ese divergencies from the technique used for lower rtebrates. Where there are large classes and the jecting must be done by the instructors alone or th student assistance, the time spent in this way ay be a real burden. The following method, devised meet this difficulty, can be used on freshly killed ecimens, and permits satisfactory dissection of the gestive, urino-genital, muscular and autonomic nerus systems.

Open the abdominal and thoracic cavities with a edian incision, starting well posteriorly, avoiding e milk glands of the nursing females. Cut through e skin on the outside of each thigh from the knee the gluteal region, and pull up the flaps of skin each side. With a hypodermic syringe inject from 0 to 400 cc of 10 per cent. formalin into the left ntricle (according to the size of the animal), until bbles appear at the nostrils. Immerse the animal 5 per cent. formalin. The cats can be injected in average time of five to eight minutes apiece. ter, when the students skin their individual cats, rhaps one out of four specimens will show slight scoloration under the skin, which will disappear bere the next laboratory period, if the animal is reaced in the 5 per cent. formalin. One specimen out ten, perhaps, will have a definite decayed spot and best discarded. After a few days, the formalin may diluted to 3 per cent. In dissecting the muscles, is helpful to rub glycerine on the parts being udied.

This is a satisfactory rough-and-ready method; it not, in any sense, a museum technique.

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A CULTURE MEDIUM FOR FREE-LIVING FLAGELLATES

THE following culture medium has been tried out r two years and may be of general use to other boratories. Whole wheat is weighed into five-gram ts, which are then put into large test tubes and 25 cc of tap water added. These are then plugged with cotton, capped with lead foil and autoclaved at fifteen pounds for two hours, which very thoroughly macerates the wheat. Tap water is again added up to 50 cc, and desired percentages of this are used after shaking. After opening a tube it is necessary to sterilize again in an Arnold sterilizer, as bacterial growth is quite vigorous in the mixture. However, a tube may be used day after day, if sterilized daily.

Varying percentages of this afford a very good medium for many protozoa. Bacterial feeders as Chilodon, Paramecium, Oicomonas and others thrive. Ochromonas, Chilomonas and several of the smaller Euglenas (E. gracilis, E. quartana, E. mutabilis) have been grown in great abundance in various dilutions and there are several species of Amoeba which likewise occur or are capable of being cultured in large numbers. It has proved best, however, for Entosiphon and Peranema. Both of these forms are easily grown in quantities sufficient for classroom use; isolation cultures of the former have been carried for over a year on this medium. In general it seems much better than cracked boiled wheat, which is often used.

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SPECIAL ARTICLES

CONCERNING PROTOPLASMIC CURRENTS ACCOMPANYING LOCOMOTION IN AMEBA

INVESTIGATORS of the mechanics of ameboid locomotion have generally agreed as to the existence of currents in the protoplasm of the progressing ameba, but there has been much disagreement as to the direction and general relations of such currents. One of the most serious contradictions is that between the observations of Rhumbler[1] and those of Jennings.[2] Rhumbler described a system of currents which was entirely in accord with his view that surface tension is an essential agency in ameboid locomotion. He asserts that the deeper protoplasm (endoplasm) flows forward. Any given portion of it, having attained a superficial position at the advancing front of the animal, then turns and moves backward at a relatively

[1] Rhumbler, L., 1898. "Physikalische Analyse von Lebenserscheinungen der Zelle." *Arch. für Entwickelungsmech. der Organismen*, 7, pp. 103–350, plates VI, VII; 100 figs. in text.

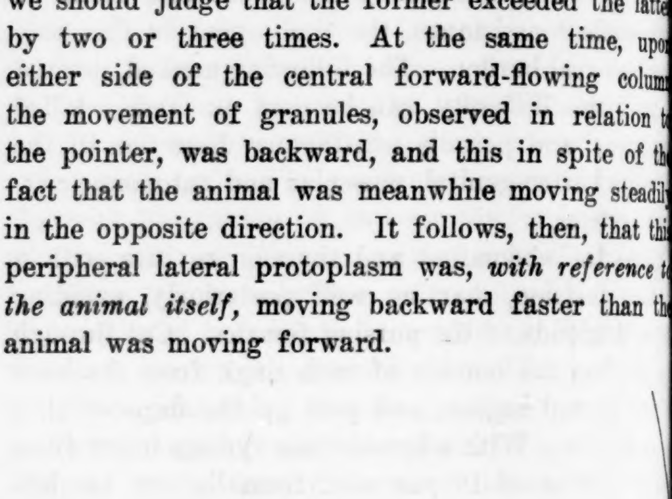
[2] Jennings, H. S., 1904. "The Movements and Reactions of Amoeba." Carnegie Institution Publication No. 16, pp. 129–234, 78 figs. Washington, D. C.

superficial level. Thus, at the anterior end of the ameba the axial forward flow is continually dispersing itself into the peripheral backward flow. The effect is that of a fountain-like system of currents at the anterior end, involving continual transformation of endoplasm into exoplasm. The necessary compensatory relations exist at the rear of the animal. Jennings, unable to corroborate Rhumbler's observations, asserts that all the protoplasm, both axial and superficial, is flowing forward, but at different velocities, the axial flow being more rapid than the peripheral flow. He therefore suggests that Rhumbler suffered an optical illusion, mistaking the relatively slower forward motion of the superficial currents for an absolute backward motion.

The observations reported in this present note were made incidentally in connection with other work on amebae. The circumstances were such that it was not practicable to turn aside for an intensive study of the current system. Nevertheless such observations as were made were so definite and seemed so free of opportunity for misinterpretation that a brief report of them is justifiable, even though it must lack much detailed information which could be desired.

The amebae upon which the observations were made were taken from hay infusion cultures which the junior author had started by inoculation from cultures maintained by Dr. James A. Dawson, of Harvard University. The amebae were of the "limax" type and were extraordinarily large. The optical conditions under which we observed them seemed especially good. The animal was placed upon an ordinary slide, with cover glass, and viewed with a Leitz No. 7 dry objective. Stationary "landmarks" or reference points for detection of motion were afforded by the edge of the field and by the common device of a hair "pointer" secured at the image level within the ocular. The setting of the field at the time when the most satisfactory observations were made, and the direction of the observed currents are shown in the figure. The ameba, whose length was equal to half or more than half of the diameter of the field, was progressing steadily across the field. The slide was so placed that the anterior end of the ameba was near the edge (F) of the field, and the pointer (P) was superposed transversely to the long axis of the ameba, usually about midway of its length, otherwise at any region where it was desired to observe motion. Internal movements of the richly granular protoplasm were perfectly easy to see.

Under these conditions currents were observed as follows. (The description refers, except as otherwise noted, to the currents observed when the microscope was focused at about the middle level of the ameba. The varying thicknesses of the arrows in the figure indicate roughly the relative velocities of the currents.) A broad column of the deeper protoplasm was, in relation to the animal itself, flowing forward, its velocity being greater at the axis of the animal and less in the more peripheral regions of the column. The velocity of the absolute forward movement of the axial protoplasm—that is, its velocity as judged in relation to the fixed pointer—greatly exceeded the velocity of the forward motion of the animal as a whole. That is, in any given time, the distance covered by a particular granule in relation to the pointer was much greater than the distance covered by the most anterior point of the ameba in relation to the edge of the field. At a rough estimate we should judge that the former exceeded the latter by two or three times. At the same time, upon either side of the central forward-flowing column the movement of granules, observed in relation to the pointer, was backward, and this in spite of the fact that the animal was meanwhile moving steadily in the opposite direction. It follows, then, that this peripheral lateral protoplasm was, *with reference to the animal itself,* moving backward faster than the animal was moving forward.



At the anterior tip of the ameba is a zone of perfectly hyaline and homogeneous looking protoplasm (H). The extent and shape of this zone remain constant and it is sharply delimited from the granular protoplasm. Just behind this hyaline zone is a region within which granules delivered by the forward axial flow may be observed to swing off laterally in curving orbits, or (as ascertained by vertical focusing) to move either up or down, to begin then their return backward via the lateral and peripheral flow. It is just here at the apex of the axial forward current that granules attain their greatest velocity. They move at relatively high speed in the centrifugal flow at the anterior end of the ameba and then, as they swing over into the peripheral backward current, the velocity diminishes. Within the peripheral backward current the velocity decreases with distance from the

anterior end until, at the region marked "x" in the figure, little or no indication of movement could be seen.

The posterior region of the ameba (behind and around the nucleus) seemed to be one of comparative stagnation. No strongly marked currents could be observed there. Behind the nucleus there were some indications of weak forward flow. Central to the regions "x – x" could occasionally be seen granules moving slowly centripetally to rejoin the forward axial current and there was some evidence of forward flow around the sides of the nucleus. The stagnation at the region "x" is apparently due either to the dying out of the peripheral backward currents from in front of that region, or to their counteraction by weak forward currents from behind.

When the microscope was focused at or near the axial level of the animal, the opposed central and peripheral currents were always perfectly clearly seen. Focusing at levels either above or below the central forward-flowing mass of protoplasm gave scarcely less satisfactory evidence of backward currents similar in velocity to the lateral currents.

It follows from all this that the relations between the axial and the peripheral currents are markedly different at the two ends of the animal. At the anterior end the transition from the axial to the peripheral flow is sharply localized within a small territory and the currents run at high speed. At the posterior end the compensating transition between the two sets of currents is effected by means of comparatively sluggish flow which is diffused throughout a territory representing one fourth or one third the length of the animal.

Such currents as we have described must involve continual interchange of the deeper and more superficial protoplasm, as conceived by Rhumbler.

In one observation, made by the senior author, the nucleus afforded a vivid exhibition of the mechanical effect of the opposite flow of the central and peripheral currents. Apparently because of the mobility of the protoplasm about it, the nucleus is constantly subject to slight alterations in position. At the moment of the observation it happened to be lying just lateral to the axis of the ameba and perhaps a little farther forward than usual, so that the surface of its medial hemisphere was contiguous with the forward-flowing axial current and the surface of its lateral hemisphere was contiguous with the backward-flowing peripheral current. Within the few seconds during which the nucleus remained in this location, its precise vertical relations within the ameba could not be ascertained. Whatever these may have been, the resultant of the effects of all the currents impinging upon the surface of the nucleus was to impart to the nucleus a rotary motion whose most conspicuous component was an apparent counter-clockwise rotation upon the vertical axis. The velocity of the rotation was rather less than that of the currents which caused it. The rotation ceased when the nucleus moved over more nearly into an axial position and, as if coming more strongly under the influence of the axial current, was swept slightly forward. In this new location it lingered for some time with slight fluctuations as if pressed by the current and yet somehow sufficiently strongly held that it could not drift down stream. In watching the nucleus one is perplexed by the fact that it is so freely movable within limits which are in no way visibly defined. Apparently freely immersed in a labile and actively flowing protoplasm, why is its position not completely at the mercy of the currents? It must possess some highly elastic anchorage. It is as if a slightly buoyant sphere, immersed in a strongly flowing stream of water, were anchored by relatively slender and extremely elastic rubber bands. Conklin,[3] in his study of the protoplasm of the egg of Crepidula, finds evidence for the existence of a highly elastic spongioplasm which constitutes a "tenuous framework" holding other cell structures in their normal positions. Mechanical agencies, such as centrifugal force, may produce great change in the configuration of cell organs, with corresponding distortion in the framework. Yet, upon removal of the disturbing agency, the elasticity of the spongioplasm is adequate to restore displaced cell organs to their normal locations. The position and movements of the ameba nucleus could be accounted for on the ground of such an elastic spongioplasmic anchorage opposing the stresses due to the protoplasmic currents.

The currents here described were seen in at least ten individuals, and the observations were distributed over four days. In no case were currents seen otherwise than as described here. We do not claim to have settled the problem of ameboid locomotion. We do not claim that such currents as we have described exist in all amebae at all times. But we shall not be easily persuaded that we have been the subject of optical illusion. If, in the particular amebae which we observed and at the times of our observations, the protoplasmic currents were not proceeding as we have described them, then we shall no longer be justified in trusting our optical sense to inform us correctly concerning the directions of traffic currents in a city street. It is scarcely exaggeration to

[3] Conklin, E. G., 1917. "Effects of Centrifugal Force on the Structure and Development of the Eggs of Crepidula." *Journ. Exper. Zool.*, 22, pp. 311–420, 124 figs.

say that our view of the former was no less clear and convincing than is our daily view of the latter.

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THE INCREASE IN THE CALCIUM OF HENS' BLOOD ACCOMPANYING EGG PRODUCTION[1]

In connection with our work on the influence of ultraviolet light on egg production we have had occasion to determine the calcium content of the blood of a fairly large number of normal laying hens. Previous experiments had shown that the amount of calcium and inorganic phosphorus in the blood of normal growing chicks was quite uniform and about the same as that of other normal animals. From this we expected to find a similar uniformity in the calcium content of the blood of mature hens. Instead of this uniformity, however, we found surprisingly great variations in the calcium content of their blood. In a lot of ten hens we found values ranging from 13 mg per 100 cc of blood to 32 mg per 10 cc. Trap-nest records were not available on these hens, so an absolute correlation of the blood calcium and egg production could not be made. It appeared, however, that the variation in the calcium content of the blood was due to the variation in egg production. The high values were obtained in the case of the hens which were in production and the low values from hens which appeared as if they were not in production.

In order to obtain reliable information on the relation of egg production to the calcium content of the blood, a series of determinations was made this year on the calcium content of the blood from normal chickens ranging in age from day-old chicks to mature laying pullets. Determinations were also made on the blood of some mature hens which were out of production because of the molting period. Other determinations were made on blood of hens that had passed through the molting period and had come into production. The determinations were made by a slightly modified Kramer-Tisdall method. The summary of the results obtained are shown in the accompanying table:

These results show quite clearly that the calcium content of the blood of hens during the period of egg production is about double that during the periods of non-production.

Age	No. of birds	Condition	Mg Ca per 100 cc of plasma High	Low	Average
1 day	25		Blood pooled		12
1 mo.	6		Blood pooled		12
2 mo.	6		Blood pooled		13
3 mo.	6		Blood pooled		13
4 mo.	6		Blood pooled		14
5 mo.	10	Immature pullets	15	12	13
5 mo.	10	Mature pullets not in production	25	15	20
5 mo.	10	Mature pullets in production	34	25	27
7 mo.	3	Capons	13	13	13
7 mo.	10	Mature cockerels	15	13	14
18 mo.	10	Molting hens not in production	18	11	14
18 mo.	3	Mature hens after molting in production	35	29	31

During the time this work was under way Riddell and Rheinhart[2] published the report of their work showing that there was a marked rise in blood calcium in pigeons at the time of egg production. The results of our work agree with theirs both in the fact that egg production is accompanied by a large increase of blood calcium and also in the fact that there is no increase in the blood calcium in male birds accompanying sexual maturity.

The increase in the blood calcium of the laying hen seems to be due to the same interplay of hormones that bring about the development of secondary sexual characteristics. At least the increase in blood calcium and the development of the characteristics by which egg production may be judged parallel each other, so that one can easily select a high or low blood calcium hen by observing these characteristics. Work is now under way to determine the relation of activity of the parathyroids to the increase of blood calcium.

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[1] Contribution No. 129, Department of Chemistry, Kansas State Agricultural College.

[2] *American Journal of Physiology*, Vol. 74.